VOLUME IV. NUMBER 4

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

W. F. KING
Chief Astronomer
Ottawa

R. F. STUPART
Director of the Meteorological Service of Canada, Toronto

J. S. PLASKETT
Dominion Observatory
Ottawa

PUBLISHED BI-MONTHLY

JULY-AUGUST, 1910

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.
FOREIGN AGENTS: WILLIAM WESLEY & SON,
28 ESSEX ST., STRAND, LONDON.

THE JOURNAL

OF THE

ROYAL ASTRONOMICAL SOCIETY

OF CANADA

VOL. IV. JULY-AUGUST, 1910. No. 4

Sir William Huggins, K.C.B., O.M.	*C. A. Chant*	253
Some Interesting Binary Stars	*J. Miller Barr*	261
A Modified Method for Nadir Observations	*R. M. Stewart*	267
Olbers: The Greatest of Amateur Astronomers	*Albert D. Watson*	271
Art and Astronomy	*John A. Paterson*	282
Meetings of the Society		
At Hamilton	*T. H. W.*	299
Notes from the Dominion Observatory		
Astrophysics	*J. S. P., W. E. H.*	300
The Seismograph	*O. K.*	302
Magnetic Observations	*O. K.*	304
Notes from the Meteorological Service		
Report of the Weather in Canada, June-July	*R. F. S.*	305
Earthquake Records at Toronto and at Victoria, B. C.	*J. V.*	308
Astronomical Notes		
Photographs of Auroræ		309
The Genesis of Various Lunar Features		309
Spiral Nebulæ		310
Light Pressure		311
Perseid Meteoric Shower, 1910		312
Argentine National Observatory		313
The Spiral Nebula *M*51 (Canum Venaticorum)		314
Stellar Motions		315
New Comet		316
New Sideral Time Piece	*J. R. C.*	316
Notes and Queries	*C. A. C.*	317
Predictions for September and October		321

Editorial communications should be addressed to C. A. Chant, University of Toronto, Toronto, Ont.

Business correspondence, remittances, etc., should be addressed to Chas. P. Sparling, Treasurer of the Society, 11 Dunbar Rd., Toronto.

Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 35 cents.

Subscription to the *Journal* is included in membership fee.

Anyone wishing to purchase a Telescope may correspond with the Secretary, Toronto.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

OFFICERS FOR 1910

Honorary President—W. F. KING, C.M.G., LL.D., Chief Astronomer, Ottawa.
President—Professor ALFRED T. DE LURY.
First Vice-President—Professor LOUIS B. STEWART
Second Vice-President—J. S. PLASKETT, B.A.
Secretary—J. R. COLLINS.
Treasurer—CHAS. P. SPARLING.
Recorder—MISS ELSIE A. DENT.
Librarian—A. SINCLAIR, M.A.
Curator—ROBERT S. DUNCAN.

Council—The above Officers and the following members:—JOSEPH POPE, C.M.G., Ottawa; REV. D. B. MARSH, D.Sc., F.R.A.S., Peterborough; Rev. I. J. KAVANAGH, S.J., D.Sc., Montreal; WM. BRUCE, Hamilton; LACHLAN GILCHRIST, M.A., Toronto; R. M. STEWART, M.A., Ottawa; and Past Presidents ANDREW ELVINS, JOHN A. PATERSON, K.C., M.A., R. F. STUPART, F.R.S.C., Professor C. A. CHANT, W. BALFOUR MUSSON; and the presiding officer at each Centre as follows: DR. OTTO KLOTZ, H. B. COLLIER, B.A., and G. PARRY JENKINS, F.R.A.S.

OTTAWA CENTRE

Local President—OTTO KLOTZ, LL.D., F.R.A.S.
Vice-President—J. S. PLASKETT, B.A.
Secretary—CARL ENGLER, B.A.
Treasurer—C. C. SMITH, B.A.
Council—R. M. STEWART, M.A., F. A. MCDIARMID, B.A., J. J. MCARTHUR, D.L.S.

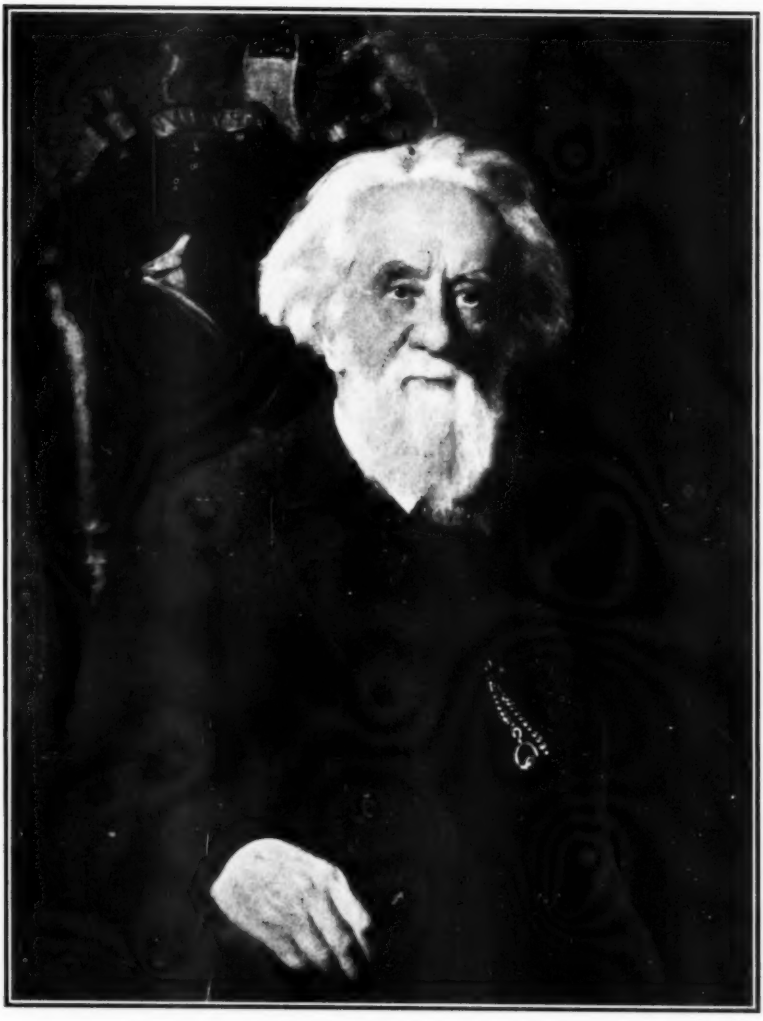
PETERBOROUGH CENTRE

Local President—H. B. COLLIER, B.A.
Vice-President—H. O. FISK
Secretary-Treasurer—REV. DR. MARSH, D.Sc., F.R.A.S.
Council—T. A. S. HAY and D. E. EASON, B.A.Sc.

HAMILTON CENTRE

Local Presdent—G. PARRY JENKINS, F.R.A.S.
First Vice-President—WILLIAM BRUCE.
Second Vice-President—E. H. DARLING, A.M.C.S., C.E.
Secretary—T. H. WINGHAM, B.A.Sc.
Treasurer—A. T. NEILL.
Council—REV. R. E. M. BRADY, D.Sc., W. A. ROBINSON, REV. J. J. MORTON.

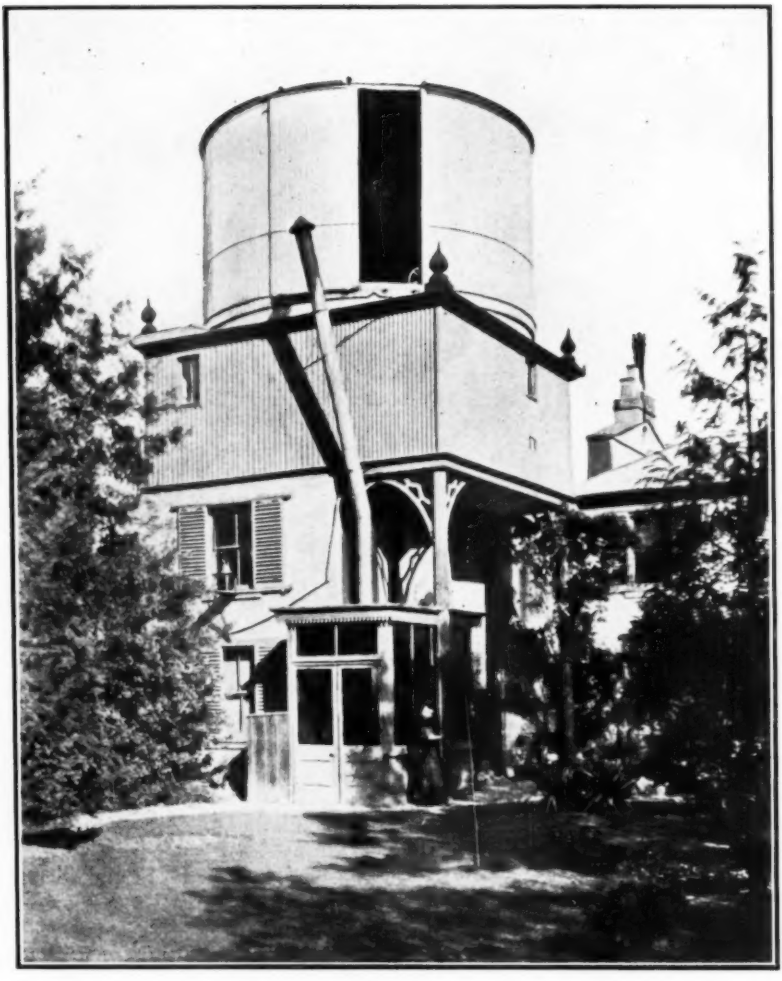
PLATE XVII.



SIR WILLIAM HUGGINS (Born 1824, Died 1910)

Made from the portrait in "The Scientific Papers of Sir William Huggins," which is a reproduction of a painting by Hon. John Collier, representing Sir William, at the age of 81, seated in the presidential chair of the Royal Society

Journal of the Royal Astronomical Society of Canada, 1910



THE OBSERVATORY OF SIR WILLIAM HUGGINS,
AT UPPER TULSE HILL, LONDON

(From "An Atlas of Representative Stellar Spectra.")

THE JOURNAL
OF THE
ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. IV. JULY-AUGUST, 1910. No. 4

SIR WILLIAM HUGGINS, K.C.B., O.M.

BY C. A. CHANT

THE story of the life of Sir William Huggins is almost synonymous with the history of that great branch of astronomical study now known as *astrophysics*. To him more than to any other scientist do we owe our knowledge of the actual nature of the heavenly bodies, of their motions in space and of the life-history of the stars. Until his time these great celestial problems were perfect mysteries and were regarded as absolutely insoluble.

William Huggins was born on February 7, 1824, the son of a London tradesman. He received his primary education at the City of London School, and then under private tutors he studied classics, mathematics and the modern languages. In addition, having a decided aptitude for science, he devoted much attention to its various branches. He acquired a good practical knowledge of chemistry, electricity, astronomy (as then understood), and for some years he assiduously studied animal and vegetable physiology. Indeed he was such an all-round scholar that he hardly knew in which branch of science to specialise, but finally he decided in favor of observational astronomy.

In 1856 Huggins purchased a house at Tulse Hill in the south of London, where he built and equipped his own observa-

tory. At first he used a 5-inch telescope by Dollond, at that time considered a large rather than a small instrument. He commenced work on the usual lines, taking transits, and observing and making drawings of planets. "Some of Jupiter," he writes in 1897, "now lying before me, I venture to think, would not compare unfavorably with drawings made with the larger instruments of the present day."

Two years later, in 1858, Huggins purchased from his friend, Rev. W. R. Dawes, an object-glass of 8 inches diameter made by Alvan Clark. Dawes parted with the glass in order to make way for one ¼-inch larger by the same maker. The price paid by Huggins was £200, which was what it had cost its former owner. The telescope was mounted equatorially and provided with clock-movement by Cooke.

The routine character of the ordinary astronomical work soon became wearisome, and a vague longing after newer methods of attacking the many problems presented by the heavenly bodies filled his mind. While filled with such thoughts the news reached him of Kirchhoff's great discovery of the constitution of the sun, the information being obtained by interpreting the dark lines in the solar spectrum.

Of his feelings on learning of Kirchhoff's success Huggins says :—

"This news was to me like the coming upon a spring of water in a dry and thirsty land. Here at last presented itself the very order of work for which in an indefinite way I was looking — namely, to extend his novel methods of research upon the sun to the other heavenly bodies. A feeling as of inspiration seized me : I felt as if I had it now in my power to lift a veil which had never before been lifted; as if a key had been put into my hands which would unlock a door which had been regarded as for ever closed to man — the veil and door behind which lay the unknown mystery of the true nature of the heavenly bodies."

Just at this time he met at a soirée of the Pharmaceutical Society, where spectroscopes were shown, his friend and neighbor, Dr. W. Allen Miller, Professor of Chemistry at King's College, and they went home together. Miller was experienced in chemical spectroscopy and Huggins explained to him what was in his mind and proposed that they join in an attempt to apply

Kirchhoff's methods to the stars. Miller was very doubtful of the possibility of success on account of the faintness of the stars and the extreme delicacy of the work, but he agreed to go to the observatory on the first clear night to make some preliminary experiments. Thus Huggins embarked on his long career of original research, which resulted in many epoch-making discoveries and brought to him the highest possible distinctions which the scientific world could give.

The first great difficulty was to secure a star spectroscope, an instrument then unknown to the optician. After an almost infinite expenditure of time and patience and skill a spectroscope suited to the purpose was constructed. Then for the first time an astronomical observatory took on the appearance of a physical laboratory. There could be seen in it a large induction coil, Leyden jars, Bunsen burners, vacuum tubes and other pieces of apparatus.

"The time was, indeed, one of strained expectation and of scientific exaltation for the astronomer, almost without parallel; for nearly every observation revealed a new fact, and almost every night's work was red-lettered by some discovery." The first published result was a paper, "On the lines in the Spectra of some of the Fixed Stars," which appeared in the *Proceedings* of the Royal Society for 1863. In this were diagrams of the spectra of Sirius, Betelgeuse and Aldebaran, and also a statement that spectra of some forty stars and of Jupiter and Mars had been observed. The immediate conclusion was that the far-distant suns of the universe are built up of the same elements that we handle upon the earth. At about this time Rutherfurd, of New York, was engaged in similar investigations, and a little later Secchi in Italy and Vogel in Germany undertook work of the same kind.

In February, 1863, a photographic outfit for using the wet collodion process was added to the observatory, but though photographs of the spectra of Sirius and Capella were obtained they did not show the dark lines expected. Twelve years later the photographic experiments were resumed with success.

Observations of the spectra of the stars were made on every fine night, and the results were communicated to the Royal Society; but in 1864 Miller was compelled to withdraw, and Huggins continued the work alone.

In the early autumn of that year occurred one of the supreme moments of the great investigator's career. For centuries the nature of the mysterious nebulæ had been an unread riddle. Many had thought that they were parts of a fiery mist out of which the orbs of heaven had slowly been fashioned, but a little before the middle of the century this view began to give way before the revelations of the great telescopes which had been constructed and which seemed to show that a nebula was only an aggregation of innumerable stars. If such were the case, the spectrum of a nebula should be a continuous band with dark absorption bands, as exhibited in the stars individually. On the evening of August 29, 1864, Huggins directed the telescope towards a planetary nebula in Draco, and looked into the attached spectroscope. No spectrum such as he had expected; but instead, a single light line! At once he recognised the true interpretation,—that the nebula was a luminous gas, not an aggregation of stars. A few days later the Great Nebula in Andromeda was scrutinised, but here the spectrum seemed continuous and extremely feeble. Out of sixty of the brighter nebulæ and clusters, about one-third gave the bright-line spectrum.

On May 16, 1866, Huggins received a letter from an unknown correspondent named John Birmingham, (who afterwards did creditable work in observing variable and red stars), stating that he had discovered on May 12 a new star in the Northern Crown, and suggesting it as an interesting subject for spectrum analysis.* That evening was fine, and soon the spectroscope

*The following extract from Huggins' lecture before the British Association for the Advancement of Science at Nottingham on August 24, 1866, may be of interest:—"Perhaps I ought to state that Mr. Barker, of London, Canada W., who announced in the *Canadian Free Press* that he observed a star in Corona on May 14, and that it was of the third magnitude, now claims, in a letter addressed to Mr. Hind, to have seen the star on May 4, from which time he states that it increased in brilliancy until the 10th, and after that day diminished in brightness."

was analysing the star's light. The view presented was strange, and up to that time unprecedented. The spectrum was of the solar type with numberless dark lines, but there also shone out a few very bright lines, at least two of which belonged to hydrogen. To account for the sudden appearance of the star and the extraordinary spectrum, it was suggested that some sudden and vast convulsion had taken place in a body so far cooled down as to give but little light, or even to be partially crusted over ; by volcanic forces, or by the disturbing approach or partial collision of another dark body.

Three faint comets, in 1866, in 1867 and in January 1868 and a brighter one in June 1868 were examined in the spectroscope, and the fact discovered that at least a part of the comet's light is peculiar to it, and the three fluted bands in its spectrum were shown to be due to the luminous vapor of carbon.

Thus in a period of about five years Huggins had been a pioneer over a vast territory. Fixed stars, nebulæ, comets and a new star were forced to reveal their mysteries. The work already done was sufficient to render any person famous. But Huggins's genius discovered other fields for the exercise of his spectroscope.

The most important of these was the measurement of the speed of a star in the line of sight. Some years before this Huggins had realised that the motion of a star in the line joining it and the earth should produce a displacement in the lines of the spectrum, but how to demonstrate and measure the effect was a most difficult problem. In 1866 a spectroscope of greater power was constructed for this research, and after two years of toilsome experimenting, filled with painful failures, a paper was presented to the Royal Society giving the foundation of the method. By many astronomers, unfamiliar with spectrum analysis, the method was not properly appreciated ; but soon afterwards the observations were confirmed by Vogel in Germany. In later times the determination of motion in the line of sight has become one of the chief branches of work in our observatories, and many

results, quite as wonderful as those obtained with Aladdin's lamp, have been achieved.

The names of Janssen and Lockyer are usually and properly associated with the observation of the solar prominences in the absence of an eclipse, but Huggins was a pioneer here also. He showed how to solve the problem and published an account of his methods, and had he not been incapacitated for work for some months by the death of his mother he would, probably, have been the first to announce actual observation of the prominences by means of the spectroscope. As a matter of fact he was the first to show how, by widening the slit-opening, the actual form of a prominence could be seen. Since then this method has been universally employed.

In 1870 the 12-foot dome of the observatory was replaced by a drum 18 feet in diameter, and in this were mounted, on the same pier, two telescopes — an achromatic of 15 inches aperture and a Cassegrain reflector with metallic specula of 18 inches aperture. These instruments were made by Grubb, and were mounted on two independent declination axes, one moving within the other, so that both were available for use at any time. In order to secure a freer horizon the observatory was built on iron pillars, so that the floor is raised 16 feet above the ground. A solid pier of brick and masonry passes up through the floor for the support of the telescope, and in the space below are two rooms for laboratory and photographic work.

In 1875, Mr. Huggins married Miss Margaret Murray, of Dublin, who proved herself an able and enthusiastic assistant to her distinguished husband. Indeed no other assistants were employed. Everything, down to the most ordinary details of instrumental and photographic preparation has been done by their own hands. To this, as well as to the unfavorable British climate, the two capable workers attributed what they considered the "comparative slowness" with which the work of the observatory proceeded; but an examination of the magnificent record of the work left behind will assure one that the progress was certainly not slow.

With the advent of the gelatine dry-plate fresh attempts were made to photograph the spectra, and now with decided success. Indeed much of the notable advance in astronomical methods and discoveries can be credited to the sensitive plate. With a master's hand Huggins adapted his apparatus to the new conditions. By employing in his spectroscope prisms of Iceland spar and lenses of rock-crystal, and attaching it to the reflecting telescope, he was able to obtain photographs of the spectra with ultra-violet light. A photograph of the spectrum of Vega was shown to the Royal Society in 1876. In the spectra of such stars as Sirius and Vega there came out in the ultra-violet region a wonderful rhythmical group of hydrogen lines, of which the well-known hydrogen lines in the visible spectrum form the lower members.

In 1879, in a paper containing maps of the photographic spectra of the stars, an attempt was made to arrange the stars in a series according to their development. There has been much speculation on this subject, which, indeed, is one of the grandest and most awe-inspiring in the entire realm of science.

In 1881 a comet bright enough to be photographed with the telescope and spectroscope appeared, and on June 22 a good photograph of the spectrum of the head was obtained. The extended spectrum confirmed the previous eye observations. There was a faint continuous spectrum with Fraunhofer lines, and also the groups of bright lines characteristic of the carbon compounds.

The great merits of Huggins as an original investigator were widely recognized. From the greatest universities in the world he received honorary degrees, and the various scientific societies enrolled him as an honorary member. He was president of the Royal Astronomical Society in 1876, of the British Association in 1891 and of the Royal Society from 1900 to 1905. On the occasion of the Diamond Jubilee in 1897 he was made a K.C.B., and when the Order of Merit was established in 1902 he was chosen as the representative of science and the letters O.M. added to his name.

Dr. Huggins was elected an honorary member of the Royal

Astronomical Society of Canada (then the Astronomical and Physical Society of Toronto) on November 16, 1891, on motion of Mr. Andrew Elvins seconded by Sir Adam Wilson. The present writer well remembers the address made by Mr. Elvins in presenting the name. In the choicest language and with a full appreciation, he gave an extended account of Huggins's great labors in astrophysics, while graceful reference to the assistance rendered by his wife was not forgotten. In 1905, when the Canadian expedition to observe the total eclipse of August 30, in Labrador, was being organised, the Council of the Society extended to Sir William Huggins an invitation to act as one of its representatives. He was unable to accept, but the letter of acknowledgment which he sent showed that our request had given him much pleasure.

In 1899 Sir William and Lady Huggins published "An Atlas of Representative Stellar Spectra." This is a magnificent folio volume. In it is an account of the instruments and methods employed, an elaborate discussion of the order of evolution of the stars, and a series of wonderful plates of stellar spectra. In 1909 appeared "The Scientific Papers of Sir William Huggins," a splendid quarto volume of over 500 pages containing a reprint of the published papers on the work of the observatory since 1856. The papers are arranged under topics and are of the greatest interest to all students of astrophysics.

Death came somewhat suddenly on May 12. Only a week before he attended a meeting of a committee connected with the publication of Sir William Herschel's works. His mind was as clear as ever, and he was full of his usual wisdom and common sense. His removal leaves a gap in world-wide science which can hardly be filled. Lady Huggins survives him but there are no children.

SOME INTERESTING BINARY STARS

By J. Miller Barr

MODERN spectrographs have brought to light, among the brighter stars, a surprisingly large number of binary systems.* In such systems the component stars revolve about their common centre of gravity in periods ranging from a few days, or even a few hours, to several years. The spectroscopic pairs are thus, in general, much closer than the visual binaries with which astronomers have been familiar since the days of Sir Wm. Herschel. Yet we cannot doubt that the two classes of objects are most intimately related. Several binaries have, indeed, been discovered which form connecting links between the ordinary visual and spectroscopic pairs. And a careful survey of the whole subject leads us almost irresistibly to the conclusion that these diverse stellar systems have had a similar origin—that they represent different stages in an orderly and harmonious process of development. To discover the nature of this process—to point out, at all events, the broad lines along which the stellar systems have been evolved—is one of the most fascinating problems of modern astronomy. The problem is one of great complexity—as may be inferred from the widely divergent results obtained by leading investigators who have grappled with its difficulties. Yet it may be possible—as we shall presently see—to obtain much new light on the subject: to secure direct evidence, such as may enable us to decide between the rival theories here referred to.

A few examples may serve to illustrate the wonderful variety which is found among these revolving stellar systems.

* A large proportion of the known spectroscopic binaries are brighter than the fifth magnitude. About one star out of every six or seven has proved to be a binary system. Among stars of the Orion type the proportion of such binaries is "not less than 1:3," according to Professor Frost.

Let us take, first, the binaries of short period, which are of special interest from our present point of view.

A very notable case, historically and scientifically, is that of the famous variable star Algol — the most familiar object of its class in the heavens. It was Goodricke, in 1783, who brought to light the *periodical* changes in this star's lustre; and he suggested that these changes might be due to the intervention of a dark body revolving about the star. This view was confirmed, nearly a century later, by a study of the star's light-curve.* Still later, viz. in 1889, Vogel found from measurements of spectrograms taken at the Potsdam Observatory that Algol was actually revolving in an orbit in conformity with the eclipse-theory. This orbit is nearly circular, its radius being about 1,000,000 miles.† Assuming that the two bodies are equal in mass,‡ we find that the bright star is about 940,000 miles in diameter, while the dark companion has a diameter of 720,000 miles, nearly.

The system of Algol stands first, in the order of discovery, on our list of known spectroscopic binaries. This list now includes more than 200 stellar systems. Among them we find several other "eclipse variables"; also a number of variable stars of the type of δ Cephei. We are thus apparently justified in assuming that all variable stars of short period represent binary systems in more or less rapid motion.

Exceptional interest attaches to the closer binaries — those in which the component stars appear to revolve almost in contact with one another. β Lyræ, *U* Pegasi, and β Cephei are examples of such close revolving systems. The period of β Lyræ (12·92 days) is relatively long for an object of this class. It

* E. C. Pickering, *Proc. Amer. Acad.*, vol. xvi., (1881), p. 27.

† *Publications of the Allegheny Observatory*, vol. i., No. 5. Algol must now be regarded as a triple system, spectrographic observations having shown that the "eclipsing-pair" is revolving about a distant centre in a period of 1·9 years. (*Astrophysical Journal*, Sept., 1908, p. 150).

‡ This assumption is probably near the truth, as the eclipsing body is doubtless of greater density than its bright primary.

follows that the mean density of the system must be quite small — "somewhat less than the density of air," according to Myers.* This star is one of the best-known variables in the sky, its light-changes having been detected by Goodricke in 1784. It is the chief representative of a most interesting type; the components being unequal in size and brightness, so that their mutual eclipses give rise to a ***double*** light-curve, with two unequal minima in each period. *U* Pegasi is another variable of the same type, but with a much shorter period, viz. 8 hours 59·7 minutes. Hence we must infer that the two bodies composing this system are much denser than the components of β Lyræ. A similar remark will hold good for the system of β Cephei, whose period of revolution — about 4 hours 34 minutes — is the shortest hitherto found for a spectroscopic binary.†

In striking contrast with the systems just described are those of the visual binaries, whose periods range from several years to unknown centuries. These visual pairs include some of the most interesting and wonderful objects in the heavens. Among them is α Centauri, our nearest neighbor in the stellar universe. The period of this system is about 81 years, and the orbit is decidedly elliptical. The mean distance between the two stars is about 2,160,000,000 miles, or more than 23 times the distance which separates us from the sun. The chief component is remarkable for its similarity in mass, brightness, and chemical composition, to our sun. Another system, with a much longer period (probably about 347 years‡) is that of Castor, the most conspicuous double-star in the Northern Hemisphere. The orbit is an ellipse of moderate eccentricity. Each of the bright components has proved to be a spectroscopic binary; the periods of revolution being respectively 2·93 and 9·22 days.§ Hence we must now look upon Castor as a "double-double" star — the most remarkable of known quadruple systems.

* *Astrophysical Journal*, Jan., 1898, p. 1.

† *Ibid.*, Nov., 1906, p. 259.

‡ Doberck, *Astr. Nach.*, No. 166, (1902), p. 145.

§ The longer period is that of the brighter star α₂ Geminorum. ("The System of Castor," *Astrophysical Journal*, June, 1906, p. 351).

The orbits of the short-period binaries seem, in general, to be very nearly circular, while those of the visual binaries of long period are more or less decidedly elliptical. The significance of this relation becomes evident when we deal with the cosmogenic problem presented by these stellar systems.

More than a quarter of a century has elapsed since G. H. Darwin propounded his now famous theory of Tidal Evolution. As is well known, this theory was originally advanced in explanation of the Earth-Moon system; but the principle was subsequently applied to the stellar binaries by Dr. T. J. J. See. "According to that theory, the components of each revolving pair were formerly united; their separation having been brought about by the rapid rotation of the original mass, due to its gradual condensation. Owing to tidal friction, the bodies thus formed by disruption of the parent mass would, in course of time, become more and more widely separated. Thus the closer spectroscopic binaries, such as β Lyræ or Algol, represent early stages in the evolutionary process; while the visual pairs (whose periods range from a few years to several centuries) exemplify much later stages in the same process. An important confirmation of this theory is afforded by recent researches on the period and light-curve of β Lyræ."* It should be added that the principle of tidal friction accounts fully for the difference in form between the stellar orbits of long and short period, as already noted.

The "fission theory," as described above, has been adversely criticised in recent papers by three well-known astronomers — Chamberlin †, Moulton ‡, and See.§ Dr. See — whose name had for many years been honorably associated with this theory — has greatly modified his former views on the subject. He now holds that the components in the closer pairs were originally separated

* "Note on the Increasing Period of β Lyræ," by Dr. Alex. W. Roberts (*Observatory*, Feb., 1906, p. 98). The quotation given above is from the writer's paper on "The Study of Variable Stars" (*Canadian Astronomical Handbook* for 1907; *Popular Astronomy*, April, 1907, p. 217).

† *Carnegie Institution, Publication 107*, p. 167.

‡ *Ibid.*, p. 157.

§ *Astr. Nach.*, 4341-42; *Popular Astronomy*, Nov., 1909, pp. 538-544.

by much wider distances. Their orbits, while thus contracting in size, have also become much less elongated in form. These changes, according to Dr. See, are due to a "resisting medium" in which the stars revolve.

Per contra, the fission-theory receives strong support from known facts relating to the multiple stars — as Mr. Henry Norris Russell has recently pointed out.* Moreover, the objections urged against this theory by Professors Moulton and Chamberlin seem to rest upon a very slight foundation.† Mr. Russell concludes that the fission-theory "may well be adopted as a working hypothesis until some evidence, either observational or theoretical, is produced to oppose it."

I have already referred to the possibility of obtaining new light on this important subject. It would seem, in fact, that the fission-theory may be subjected to a crucial test by determining the periods of close binaries at various epochs, with a view to the detection of gradual or "secular" changes. There are two well-known cases in which such changes have undoubtedly occurred. The period of β Lyræ has slowly increased in conformity with Darwin's theory. *Per contra*, the observations of δ Cephei show a gradual *decrease* in the period of this variable. In other cases (as that of Algol) the period is subject to changes of a recurrent or cyclical nature. If, however, we take a sufficiently large number of binaries and discuss their periods in the manner suggested, it is clear that the influence of cyclical changes will, in the mean, be eliminated. We should then be able to say whether, *on the whole*, the periods of such binaries are increasing or diminishing. This would be an important step in advance; and it is hoped that such a step may be taken in the near future.

From our present standpoint, peculiar interest attaches to the spectroscopic binaries and variables of very short period — such as β Cephei, *XX* Cygni, or *W* Ursæ Majoris. In such cases, the influence of tidal friction might well become perceptible even in the course of a few years. As an example, we may

* "On the Origin of Binary Stars," *Astrophysical Journal*, Apr., 1910, p. 185.

† *Ibid.*, pp. 203–207.

take the system of β Cephei, whose approximate period is $4^h\,34^m$. A secular change in the period of only *ten seconds per century* (*i. e.*, $0^s{\cdot}1$ per annum or $0^s{\cdot}00005$ in each revolution) would in *ten years* cause a large time-shift — about $2^h\,40^m$ — in the occurrence of a given phase. The continued observation of such close systems is thus likely to yield results of great theoretical value. It is quite probable that some of these close systems may have been formed — presumably by disruption of stars in rapid rotation — within historic times. Astronomers, indeed, may yet have the privilege of studying in detail those special changes in brightness or spectral quality which doubtless occur at the birth of a binary star.

ST. CATHARINES, ONT.,
May 10, 1910.

A MODIFIED METHOD FOR NADIR OBSERVATIONS

By R. M. Stewart

IN the ordinary method of nadir observation, by attempting to make a moveable thread coincide with its reflected image, there is always present in the observer's mind (at least in the case of the writer) a feeling of uncertainty as to whether the coincidence is exact, and a question as to whether settings may not habitually be made asymmetrically. This point can of course be decided, and its influence eliminated, by making observations facing both north and south, but with most meridian circles this is not convenient. A modification of the usual arrangements has been adopted here, which seems to avoid the difficulty, and is, so far as known to the writer, new ; the making of a pointing consists in the *obliteration* of a *bright* reflected image (in a dark field) by the micrometer wire, itself invisible ; since the phenomenon to be observed is merely the disappearance of an image, without any preception of the means of extinction, there would appear to be no room for the existence of any systematic personal effect. The method is also one of extreme delicacy, and the impression gained while making pointings is that the accuracy is considerably greater than in the ordinary method.

The Ottawa meridian circle, by Troughton and Simms, is furnished with the usual type of collimating eye-piece, in which a plane inclined glass is interposed between the threads and the magnifying system ; the latter consists of an object-lens, which forms a real image of the threads, and a Ramsden eye-piece which magnifies this image. The magnification depends on the distance of the object-lens from the threads ; as at present adjusted the magnification of the whole system (telescope-objective and eye-piece) is about 200. For nadir and level readings artificial light is used exclusively ; the illumination is obtained from two electric lamps, placed at a distance of several feet, respec-

tively east and west of the position of the micrometer head when the telescope points to the nadir. On account of the high magnification used, and because the eye-piece is not readily moveable in right ascension independently of the transit micrometer threads, it is necessary for readings of level error that the inclination of the reflector should be approximately in the meridian, in order that the transit threads may be in the middle of the field of view ; this is provided for by a small adjustable plane mirror attached outside the collimating eye-piece, which throws the beam of rays from either lamp into the eye-piece along the plane of the meridian, to be again reflected downward to the threads.

The eye-piece and mirror are first adjusted in the ordinary way, showing the threads and their reflected images in a bright field. If the collimating eye-piece (or the attached mirror) is then rotated slightly the bright field will disappear, leaving the reflected images of the transit wires bright, while the wires themselves are invisible in the dark field. Settings are then made by obliterating the reflected images with the wires themselves. To obtain bright images of the declination wires the eye-piece is rotated back to its original position and the bright field made to disappear by changing the inclination of the plane glass reflector, when settings can be made as before.

The principle involved is of course simply that of oblique illumination, as universally used for obtaining bright-wire images, the distinction being that, in this case the light is travelling obliquely towards the *object end ;* in fact, on viewing the threads, so illuminated, from the object end (by means of a collimator), they appear bright in a dark field. The same result could no doubt be attained by condensing the illumination on the threads by a lens whose central part is diaphragmed, as for obtaining bright-wire illumination in a broken-type telescope.

In practice, the wires are brought very nearly into coincidence before the bright field is removed, so that only a slight movement is required to make the coincidence complete. A complete reading for level or nadir point consists of ten pointings ; there is a small systematic difference depending on the side from which

the threads are illuminated ; to eliminate this the direction of illumination is reversed after five pointings have been made. The best results are obtained if the source of light be fairly narrow ; this can easily be managed by interposing a screen. In attempting this method for the first time some little difficulty may be experienced in getting the reflected images bright and well defined, but after a little experience the adjustment is a matter of a few seconds only.

To obtain the probable error of a single pointing, 100 complete readings for level error (comprising 1000 separate pointings) were examined. These readings were made in the ordinary course of work during the period April 3 to June 18. The adopted value of one revolution of the micrometer screw was 48″·24. The micrometer head is sub-divided to hundredths, and estimated to thousandths. The probable error was computed on the assumption of 1000 observations for the determination of 100 unknown quantities, by the formula

$$r = \cdot 6745 \sqrt{\frac{[v^2]}{900}},$$

where each v represents the residual of a single pointing from the mean of ten ; the value of r obtained was $\pm 0''\cdot 065$. The following are the numbers of residuals ·005 rev. and greater.

·005	rev. (0″·24)	19
·006	"	5
·007	"	4
·008	"	1
·009	"	1

The largest probable error (of a single pointing) as obtained from a single set of 10 pointings was $\pm 0''\cdot 135$; on this occasion the observation note is " Definition poor except occasionally."

The same set of observations was examined for differences depending on the direction of illumination. It was found that the deduced level error was greater when the light fell on the threads obliquely from the east ; the average difference was

0″·045. Though this quantity is extremely small, the observations show that it is undoubtedly real. It no doubt arises from the : aterial size of the threads, and will presumably be eliminated in the mean.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
August, 1910.

OLBERS: THE GREATEST OF AMATEUR ASTRONOMERS

By Albert D. Watson

WE all, quite naturally, delight in brilliant amateurs. When young Herrocks, the pride of English astronomers, claimed, despite the authority of the great Kepler, that Venus would, on November 24, 1639, transit the sun, the event proving his prediction correct, all Englishmen were pardonably elated. When the Saxon farmer, Palitsch, with his telescope eight feet long, succeeded, on Christmas Day, 1758, in finding Halley's Comet, nearly a month before the astronomers royal, there was similar gratification. None share this pride in the success of the amateurs more fully than the astronomers by profession.

It must not be supposed that the enthusiasm and faithfulness of the amateur would not be greatly assisted by instruments of precision, but the chief glory of the amateur is that, without a perfect equipment, he so often accomplishes so much. Indeed, even the professional astronomer, with the most complete armamentarium, can accomplish little without these essentials of faithfulness and enthusiasm which are the chief recourse of the amateur.

In January of the present year, an interesting comet was discovered by mere chance or as near to chance as things ever come. The discoverer had little, if any, interest in astronomy and has even now no standing in the scientific world. Such a one is not an amateur. If there is any difference, the amateur often takes a deeper interest in astronomy than does the astronomer by profession. What could exceed the interest which led the subject of this sketch to spend the greater part of almost every clear night for over fifty years observing the heavens, while his days were devoted to the practice of an arduous profession?

Olbers was an amateur throughout his distinguished career. On most of the theories which found expression and courted investigation during his life time, he had something interesting to say. His communications were published in the form of correspondence, memoirs, magazine articles and letters to scientific journals. He was in communication with most of the leaders of thought, and all his letters were dignified and forceful in language and some of them were final in effect.

Olbers belongs to the modern scientific period. He became an august figure among those great men who were the authorities in science at the beginning of the last century — Herschel, Laplace, Bode, Von Zach, Piazzi, Harding, Struve, Pons, Gauss, Bessel, Legrange and Fraunhofer. To all these, he was an authority, and in some important fields of his favorite science, his thought and theory dominated them all. This was particularly the case in reference to comets and the minor planets, regarding which he was, in some respects, the chief authority. The purely observational period of astronomy had long past. The age when theories were based on observation without reference to mathematics, the age, for instance, of Copernicus was ended two hundred years before Olbers' birth. Kepler had published his laws and Newton had explained them in his principles and passed to his immortal place in the pantheon of science long before Olbers was born. He belongs to the age of Laplace, who published his nebular hypothesis one year before Olbers made known his new method of computing cometary orbits.

Heinrich Wilhelm Matthias Olbers was born in 1758, at Arbergen, a village near the North German City of Bremen. His father was minister to the protestant church in the village. While still a child, this thorough little fellow was passionately devoted to the study of the heavens. He was evidently a born astronomer.

When 15 years of age, he was sent to school at Göttingen, where he studied medicine and in 1770, when 21, received his doctorate in that profession. He then established himself in Bremen and became a busy and successful practitioner. Although

he published several articles treating of his professional work, in none of these did he contribute substantially to the real progress of medical science or art, which he practiced for over forty years, retiring from active work in 1823.

It is entirely to his services as an astronomer that Olbers owes his celebrity. These services began while he was a student at Göttingen. There he took a course in mathematics under Kæstner and, while watching at the bedside of a fellow-student, devised a new method* of computing cometary orbits. This method was published by Von Zach under the title "Ueber the leichteste und bequemste methode de Bahn eines cometen zu berechnen." A table of 87 calculated cometary orbits was appended. These were increased by Encke, in a second edition, to 178, and, in a third edition, by Galle, to 242.

In 1795, Olbers published a memoir relating to the coruscations which sometimes give the tails of comets a shimmering appearance such as is observed in the Aurora Borealis. Hitherto, this phenomenon had been supposed to be a quality inherent in the comet itself, but Olbers attributed it to our atmosphere. He showed that light arriving from different portions of a long cometary train must, because of the time elapsing during the passage of the light, arrive at our point of vision at widely different moments proportionate to the distances from the earth. It is, therefore, clear that these apparent undulations of comet's tails must in reality be due to conditions of our own atmosphere, for "If the coruscations were caused by some electrical emanation from the head of the comet, even though it occupied but one second in passing over the whole surface, several minutes must necessarily elapse before *we* could see it reach the tail. But this

*(This method, devised by Olbers while he was yet a student, is still in use in some cases, and is founded on the principle that if $a\ c$ be the chord between the extreme positions of the comet, in its orbit, and $A\ C$ the similar chord of the earth's path, the radii vectores at the middle position cut $a\ c$ and $A\ C$ proportionately to the times occupied in describing the arcs, a supposition which though not mathematically exact, is but little in error if the intervals between the observations be pretty nearly equal and the arcs described small. See *Ency. Brit.*, Vol. VI., page 182).

slow movement is contrary to observation, the pulsations being almost instantaneous."

Prior to the time of Olbers, it had been generally supposed that comets carried their tails along with them as component parts of their constitution. After the appearance of the remarkable comet of 1811, whose luminous train actually extended over 100,000,000 miles, Olbers published a memoir entitled "Ueber den Schweif des grossen Cometen von 1811," in which he reasoned out what is known as his electrical theory of comets' tails, suggesting that the diffusive envelope surrounding the head was the result of two opposite electrical forces, solar and cometary, that these at first balance each other only to be swept backwards later into a tail. He divided comets into three classes (1) those with no solar repulsion, consequently, with no train, (2) those acted on only by solar repulsion and exhibiting a tail, but with no emanation towards the sun, (3) those like that of 1811 giving evidence of action in both directions.

The "electrical theory" which has had restatement of late, was rightly regarded by Zöllner as having been first traversed by Olbers. Bessel, in his Olbers correspondence most emphatically declares the emission of the tail to be an electrical phenomenon.

The relation existing between the form of a cometary train and the matter of which it is composed was also the subject of a statement by Olbers. He claimed that the curvature of the tail, so often noticed, depends upon the relation of the comet's orbital velocity to that with which the matter composing the luminous tail recedes from the head. The swifter the out-rush of cometary vapor the straighter the tail. As the velocity of the vapors depend on their composition, if strongly dissimilar substances are found in the tail of a comet, multiple tails are developed. He attributed multiple envelopes of the head also to varying repulsions by the comet itself of different kinds of matter composing its envelopes.

Eighteen years after the death of Olbers, his theory of unequal repulsions was signally illustrated in Donati's beautiful comet of 1858. The triple tail was said to be "a visible solar

analysis of cometary matter." From Olbers' time, it was realized that comets' tails are emanations of highly rarefied gases which are lost to the comet while it traverses its course near to the sun. Three years after his death the comet of 1843, in some respects the most wonderful of all comets, with a tail that reached 200,000,000 million miles in length, swept past its nearest sun-point at the rate of 366 miles per second, a rate which, if it had continued, at its short perihelion distance, would have carried it completely around the sun in two hours. It described half of its entire curvature of orbit in two hours and eleven minutes, the other half requiring many hundreds of years to accomplish. This comet showed clearly that the tail is no fixed appendage. No such train, many millions of miles in length, could be whisked from one side of the sun to the other in one hundred and thirty-one minutes. Comets tails must, therefore, be highly rarefied matter out-rushing with inconceivable velocity, The greater part of these tails must be permanently lost to the nucleus. Thus Olbers' theory as to cometary tails was strongly sustained.

Though Olbers did not discover many new comets, he observed from his upper room nearly all the comets that appeared throughout half a century.

The comet of 1811 and Halley's Comet, during its apparition in 1835, each passed centrally over large stars so that, in each case, the star appeared to be the nucleus of the comet, yet there was no diminution of stellar brightness. Halley's comet in 1835 was observed by Olbers to pass before a star so small as to be unseen by the unassisted vision. The relative positions were such as to constitute a stellar occultation, yet there was not the slightest diminution of the star's light. The tenuous nature of the cometary substance has had complete confirmation in many similar reports of subsequent observations.

On June 26th, 1819, while the head of a comet passed over the face of the sun, the earth was in all probability involved in its tail. This was not known till a month afterwards when the fact transpired as the result of the calculations of Olbers.

In March 1815, having discovered a comet without a visible

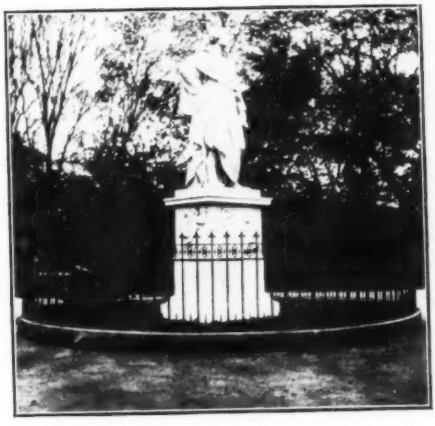
nucleus, Olbers computed its period, predictating its return in 72·45 years it was seen again in 1887 when its computed period period was verified. In 1826 Olbers published a paper in which he sought to show the possibility that a comet might come into collision with the earth. This is a position which nobody now would oppose, although the likelihood of such a collision is extremely remote.

Into the stellar fields, Olbers made many interesting excursions. He observed that the variable star χ Cygni had been constantly lengthening its period. In the discussion as to the infinity of the star-deeps, he pointed to the fact that the transparency of celestial space is very defective owing to a law by virtue of which the light of the more distant stars is enfeebled in a measure out of proportion to their distance. The extinction of light proceeding in geometrical pregression, while the distance increases in arithmetical, the space-penetrating power of the telescope is limited to a range far within what distance alone would otherwise assign. This, Olbers suggested, might explain why we cannot see more deeply into the celestial spaces although perchance the stars may reach to infinite depths.

Soon after celestial distances were first measured, it was noticed that the orbits of the planets are placed at somewhat regular distances from the sun, the distance outside of Mercury doubling with each additional planet. The fact that Bode suggested this, has immortalized his name. But Bode's "Law" had one exception. In the wide space between Mars and Jupiter no planet had yet been found. Through the exertions of Von Zach, it was arranged that twenty-four astronomers should divide the Zodiac among them in search of the planet to complete the series between Saturn and the sun.

A place on this board of search was assigned to Piazzi, the director of the observatory at Palermo, in Sicily, but before receiving his assignment, he had, on the first day of the nineteenth century, discovered the planet Ceres. He observed it for six weeks after which he was taken seriously ill and the new planet was lost in the sun's rays. Piazza had written to two

PLATE XIX.



OLBERS MONUMENT, BREMEN

different astronomers, Oriani, of Milan, and Bode, giving them a brief account of the discovery, but they did not receive his communications till late in March, and early in April.* On the last night of the year Von Zach rediscovered the missing planet and on the next night it was rediscovered independently by Olbers, in Bremen, just one year after its first discovery by Piazzi, of Palmero. Three months later (March 28, 1802,) Olbers found a second minor planet to which he gave the name Pallas.

These planets were very small, neither being more than 200 miles in diameter. Both were found to be in almost perfect accord with Bode's law of distances, and nearly equidistant from the sun. Why where there two instead of one? Olbers advanced a theory which had a notable vogue and was accepted during the greater part of the century. He suggested that they were fragments of a planet which had been disentegrated by some internal force or by some external collision. He predicted that if this theory were correct, other small bodies would be found at a similar distance from the sun.

As the orbits of the fragments of an exploded planet must intersect at two points, he advised that search be made in Virgo where Ceres had been rediscovered and where Pallas also had been found. and also in Cetus which was the other point of intersection if Virgo was to be taken as one.

The two bodies already discovered were somewhat eccentric and the second was inclined to an angle of over 34 degrees to the ecliptic. These peculiarities supported Olbers' theory and consequently telescopes were directed towards Virgo and Cetus with the hope that other fragments of the defunct planet might be found. In September, 1804. Harding found a third body, Juno, which also was in the belt of Ceres and Pallas, and had a great eccentricity and a large angle of inclination to the ecliptic. What was still more remarkable, this third body was found in

* Meanwhile Hegel, a young philosopher of Jena had published a dissertation showing in the most lucid manner that the number of the planets could not possibly exceed seven.

Cetus where Olbers had directed the astronomers to look for such bodies.

Olbers devoted much time to the search and was rewarded on March 29, 1807, by the discovery in Virgo of a fourth body in the same distance belt. Both eccentricity and ultra-zodiacal positions were in this case less marked than in those of Pallas and Juno, and yet were sufficiently different from all the larger planets to place it in a class with its companions. Moreover it had been discovered in Virgo, one of the intersecting points named by Olbers as likely to be fruitful fields for research.

No other minor planets were discovered during the life of Olbers. Of the four already known, two had been first seen and a third independently rediscovered by Olbers himself, who had also furnished a theory as to their origin which satisfied the astronomers of his time, some of whom received it in a far wider field than that to which Olbers himself applied it. Legrange held that as a supplement to the nebular theory of Laplace, it gave "a complete view of the origin of the planetary system more conformable with nature and mechanical laws than any yet proposed." He suggested also that the theory explained the eccentric orbits of the comets, a position never taken even by Olbers himself.

Further investigation has not sustained Olbers' hypothesis. At first, the evidence seemed overwhelmingly to support it, but this was because of Olbers' brilliant predictions which were in line with his theory, and led observers to look chiefly where they would be most likely to find evidence to confirm his view. Had they looked elsewhere, they would have found adverse evidence as, indeed, others did in later years. All the support seemed to come in the beginning, all the contrary evidence, subsequently and more slowly. A brilliant generalization has perished in a storm of adverse particulars.

Newcomb has observed that the elements of a description such as that involved in the Olbers hypothesis could not be traced back to any great distance in time, and after all, we do not know the origin of the minor planets.

Up to the time of his death, Olbers cherished the idea of an exploded planet. Doubtless, when in 1826, he showed that a comet might come into collision with the earth, he had the other theory in his mind. The great astronomers of his age agreed with him, and not without reason. The four planets then discovered were nearly in the same mean distance from the sun, they were eccentric and ultra-zodiacal, were thought to manifest variability, a fact attributed to their shapes, which were supposed to resemble potsherds or broken pieces of a world. The best that can be said of Olbers' theory to-day is that it has never been disproved.

How Olbers could spend, as he did, the greater part of each night in his little observatory and yet devote his entire day to his profession, requiring never more than four hours sleep out of the twenty-four, is a puzzle, and yet his distinguished contemporary and fellow-countryman, Humbolt declared that, till he was sixty years of age, he required each night not more than two hours sleep, but as he grew older found that he needed four. Possibly these men had learned the happy art, happy indeed in the case of an astronomer, of sleeping as much in one or two hours as most do in three or four. This might be termed sleeping intensified, for it is said that Humbolt slept like a log.

It is interesting to note that Olbers' house-observatory was equipped with small but excellent instruments, most of which were made in England.

The genial disposition of Olbers cannot be illustrated better than by his correspondence with Bessel. As a merchant's clerk, with elaborate care Bessel when only 20 years of age, had deduced from Herrick's observations on Halley's Comet at its apparition in 1607, an orbit of that celebrated but difficult object. Olbers was twenty-five years his senior and had a reputation unrivalled in the field of cometary research. It was, therefore, most fitting that Bessel should pay homage to his countryman by sending the result of his computations to the Bremen physician. Olbers welcomed with surprise and delight such a work coming from a merchant's clerk of twenty summers. The

French Academy had once crowned a similar performance. Now a boy of twenty, self-taught while snatching a few hours from those devoted to sleep by others of his age and station, had accomplished a great mathematical result.

Olbers sent the paper to Von Zach for publication noting the particulars, and immediately Bessel was a name familiar to the astronomical world. Two years after this, Olbers obtained for Bessel the offer of the place in Lilienthal vacated by Harding who had been promoted to Göttingen in 1805. The salary offered was only one hundred thalers, and Bessel was by this time in the way towards comparative affluence in mercantile pursuits, the choice cost him, therefore. a good deal of thought, but astronomy prevailed. He chose poverty and the stars, and was rewarded by the words of Olbers who, when his life work was nearly finished, declared that the greatest service he had ever rendered to astronomical science was that of having discerned, directed and promoted the genius of Friedrich Wilhelm Bessel, who has since been characterized as the greatest astronomer of the nineteenth century.

As a citizen, Olbers was much respected by his contemporaries, who deputed him to assist at the baptism of the King of Rome in 1810. His name is found as a member of the corps legislatif in Paris in 1812-13.

Olbers died in 1840, beloved and honored by all who knew him. As a mark of the esteem in which his services to astronomical science were held, he received honors from many sources. German universities everywhere throughout the realm honored him with degrees, and the princes of science showered on him the marks of their esteem. In 1804 he was elected a Fellow of the Royal Society of London. In Russia he was made a Knight of Dannebroga and also a Knight of the Order of the Red Eagle. He was elected to membership in the Academy of Sciences of Paris in 1829, and in 1830, the jubilee of his doctorate, a medal was struck in his honor.

After his death in 1840, at the age of 81 years, his bust was placed in the public library in his own city. A monument to his

memory stands in one of the public parks in Bremen. On the front of the monument are the name and dates of birth and death of Dr. Olbers. The words "Pallas" and "Vesta" are engraved on the left and right sides respectively of the pedestal.

I am indebted to Professor Dr. Oskar Henke, of Bremen, for information and photograph.

ART AND ASTRONOMY

By John A. Paterson

IT was once my privilege to hear a lecture upon "Architecture" delivered by one who was then a fellow citizen. He prefaced his address by disclaiming all practical knowledge of his subject and declaring that he had but a feeble grasp of the mechanical principles necessarily involved in building a chicken coop. And yet that gentleman succeeded in not only interesting but also (what was of far more importance) instructing his audience. Hard, unyielding truth is the bed rock of science, and truth nurses in her bosom gentle and lovely art, and that same truth compels me to say that as to any technical knowledge of art, I am in my swaddling clothes and know less about painting than about the appearance of the North Pole. And yet I dare to stand on this platform and venture to hold up the lamp of instruction.

Astronomy has been well called the Queen of all the Sciences. She has sat enthroned amid the centuries, the objects of her investigation ante-date time. Before the beginning, set forth in Genesis, when Chaos reigned, and there were no heavens and no earth, when undigested world-stuff and nebulous mist filled space, the fabric of nature which astronomers now study and the riddles of which they seek to interpret, was being slowly formed to make a living habitation and resting place for Art and her myriad worshippers. But yet Art in a sense is the twin sister of Science. Science and Art may be said to be investigators of truth. Science inquires for the sake of knowledge; Art for the sake of production. When Science engages in productive application, it then becomes Art. The object of science is knowledge, and knowledge is its own reward. The objects of art are works. In art, truth is the means to an end. In science, truth is the only end. Astronomy teaches us the science of the stars, of world making,

traces out for us the gradations of aggregating systems and shaping orbs, how the great Architect upon scientific principles, dynamical and chemical, with the force of gravity as the mighty dynamo to move invisible atoms as well as gigantic, far flung unshaped nebulæ. Gravity too is the adamantine power to bind together the elements of sun, satellite and sphere, and thus He moulds worlds and creates world systems. Art the producer then stands beside science the teacher — art in one sense is the perfection of nature. All things are artificial for nature is the art of God. Young in his "Night's Thoughts" says "the course of nature is the art of God," and Pope, in his "Essay on Man," says "All nature is but art." But apart from the activities of art as an embodiment of the constructive faculty, art in yet another sense may be viewed as an embodiment of these higher faculties that betoken the development of mankind far beyond the rude savagery of nature, where the æsthetic faculties reign supreme. In that advanced stage it may be safely premised that whatever branch of any pursuit ministers to the bodily comforts and regards material uses is comparatively ignoble, and whatever part is addressed to the mind only is comparatively noble. Astronomy more completely meets aims by investigating the nature of the solar corona and tracing the orbit of a dark, and therefore, invisible sun, than by teaching the laws of navigation or practicing the base mechanic exercise of writing almanacs at so many shillings a page. The artist more completely meets the higher aims of art, by putting on canvass the stooping sun upgathering his spent shafts and putting them back into his golden quiver, and thus painting for eternity, than when he sketches heads and landscapes for some illustrated monthly. The topmost Alp of astronomical research contains no golden ingot; the cliffs there are barren of that which helps material things; to reach them is "to scorn delights and live laborious days" and nights too. Neither are the highest reaches of art understood by the vulgar. They are too transcendant, but they have their own incitement. That is well illustrated by the story of the great Greek sculptor, Phidias, who at a great height from

the ground carved an eye-lid of the Olympian Jove as he strove to realize the Homeric picture

> "The sun of Saturn gave
> The nod with his dark brows. The ambrosial curls
> Upon the Sovereign one's immortal head
> Were shaken, and with them the mighty Mount
> Olympus trembled."

Some unappreciative friend asked the artist why he took so much pains with the delicate carving of the eye-lid when no man could discern its beauty from the ground. Phidias, filled with artistic instinct, replied "Ah! but the gods see it."

The true artist and the true scientist are both apostles with a message as true as he who heard the voice speaking to him, and inspired him with that divine afflatus,—

> "Woe is unto me if I preach not the gospel."

A great painter was once asked which he regarded as his greatest painting. He answered "The one I am about to paint." He grew from more to more. I ask "Which is the greatest discovery of astronomy?" and I answer "The discovery that is about to be made." This science grows too from more to more; the ocean of triumphant progress is illimitable. There stands no high, terminating pillar marked "Ne plus ultra:" discovery will never proclaim any proud period and her work accomplished. But though the individual artist may advance in his art in his power to interpret nature, whether he be an actor, artist or sculptor, can the dramatic art, the painting art or the moulding and carving art in themselves improve beyond a limit? Nature herself is the same from age to age, though old she never ages; time writes no wrinkle on her brow, and as the actor, the artist and sculptor reach their end, when they imitate nature, is there not a goal to their development? When Apelles painted grapes so naturally that the birds of the air pecked at them, and when Zeuxis painted a curtain so naturally that his rival artist cried triumphantly to cast it aside that the picture might be seen, what more could an artist in color do? And what more could future generations do than produce other artists who could do likewise?

for nature has reached her limit, and if man attempts to excel nature then he attempts the impossible and produces some vulgar embellishment or gross caricature. The greatest masters of all the greatest schools, Phidias, Titian or Sir Joshua Reynolds all tried to make human creatures as like human creatures as they could. This must be true of all imitative arts and is true of the fine or liberal arts as music, eloquence, sculpture, painting, acting. The useful arts or practical arts in their multitudinous adaptations of means to the end, in overcoming the forces of nature, in making hard lives easier, in making two blades of grass grow where formerly only one grew, all these like scientific truth move forward. The possibilities of one year become the probabilities of the next, and they in turn become the certain accomplishments of the next further on. And yet, notwithstanding some distinctions, the artist and the scientist, representing a higher culture, stand hand in hand as under a clearer sky, and with a farther and brighter vision than at the time when the curse of "In the sweat of thy face shalt thou eat bread till thou return unto the ground" was pronounced upon human race — Art and Science, like twin sisters, represent the Empire of Thought. The Empire of Force has been, the Empire of Thought is now with us; the triumphs of the one vanish, they are only victories; the triumphs of the other endure, they are conquests. Carlyle tells us that the plough share of physical force has been driven over this planet from the time of Xerxes to that of Bonaparte, and the earth divisions they made have all been blotted out over and over again and their throne-machinery and kingdom-making have vanished. — Not so the work of the world's great thinkers and scholars and artists and scientists — that still stands. The La Places, the Newtons, the Shakespeares, the Titians, the Mozarts, who by their works have ennobled humanity, live yet and their works yet do praise them. I cannot forbear remembering how well and how forcibly the same writer more fully expresses that thought. "When Tamerlane," he says, "had finished building his pyramid of 70,000 human skulls and was seen standing at the gate of Damascus,

glittering in steel with his battle axe on his shoulder, till his fierce hosts filed out to new victories and new carnage, the pale onlooker might have fancied that nature was in her death-throes, for havoc and despair had taken possession of the earth — the sun of manhood seemed setting in blood. Yet it might be on that very gala day of Tamerlane's a little boy was playing nine pins on the street of Mentz, whose history was more important to men than that of twenty Tamerlanes. The Tartar Khan, with his shaggy demons of the wilderness, has passed away like a whirlwind to be forgotten forever, but that German artisan has wrought a benefit which is yet immeasurably expanding itself, and will continue to expand itself through all centuries and through all times. What are the conquests and expeditions of whole corporations of captains from Walter the Penniless to Napoleon Bonaparte, compared with these moveable types of Johannes Faust? Truly it is a mortifying thing for your conqueror to reflect how perishable is the metal which he hammers with such violence, how the kind earth will soon shroud up his bloody foot prints, and all that he achieved and skilfully piled together will be but like his own canvas city of a camp — this evening loud with life — to-morrow all struck and vanished — a few earth pits and heaps of straw!"

And thus it is that although the corridors of time may re-echo with the clang and clash of broils and battles, and the men of that neighborhood and of that epoch may hear them, yet not by material but by mental power, by culture, influence and by general force are worlds governed and nations moulded. Thought is noiseless and moral power is gentle, but oh! how mighty and how all pervading. It is the dynamics of the intellect, the influence of culture and the power of the heart that after all moves and compels and lives.

When I look through a telescope into the depths of space, I feel overwhelmed with awe, for I know God has written His word here in these Scriptures of the Sky, and gazing into that abyss, is akin to entering into a vast cathedral and reading in some far away crypt, a new manuscript traced by God's own

finger in brilliant letters revealing to trembling sons of men the methods of His creative power, and exhibiting fresh proofs of His most holy and lofty attributes.

The study of astronomy reveals to us volumes of the liberal arts for the investigation of her worshippers. Urania, the fair muse of astronomy, holds in her hands for our study all the liberal arts,— poetry, architecture, sculpture, eloquence, music, painting,— everything upon which the æsthetic faculty of our God-given human nature may truly revel is here. Do we want poetry? It is here written on the sable skirts of the night in letters that have never faded since "the beginning" and will form an eternal blazon till time shall be no more. Poetry has something in it of divineness; it raises the mind to high contemplation. Astronomy, as she ranges in her search through an illimitable universe, and lifts us from Nature to nature's God, appeals to and arouses all the poetic instincts of our nature. No study can be more elevating, none can be more entrancing. Contemplate for a moment the scale upon which the universe is built, and try to describe it in miles. The mind then feebly struggles with bewildering groups of figures and at the best gropes in the gloom of a multiplying and ever multiplying jargon of statistics. Even when we take as our foot rule the sun's distance from us of 93,000,000 miles, it does not help us; when we take as our unit of measurement the distance light travels in a year, or a light-year as it is called, even then we are bewildered in a whirl of darkness and difficulty. A recent writer measures the magnitude of the universe by an ingenious comparison and thus supplies a crutch to our halting faculty of conceiving immeasurable distances. A certain species of spider can spin a thread of such surpassing tenuity that a pound weight of it extended would circle the earth at the equator, and ten pounds of it would be required to stretch to the moon. It would take nearly two tons of it to stretch to the sun and about 550,000 tons to reach to the nearest fixed star. Let us take another conception — some diligent Bible student has counted the letters in the Bible from the first letter of Genesis to the last letter of Revela-

tion and there are in all over 3,586,086. If we imagine each of these letters set apart from its neighbor about 60,000 miles, then the distance from the first to the last would measure about 215 billions of miles, the distance of the North Star from the earth. The leaves of many trees in the vast African forests are preyed upon by minute insects and each of these has its own little retinue of parasites. If one of these monads were destroyed, the forest would still flourish as gloriously as ever, its strength would be unabated, its beauty as undimmed and its vastness as undiminished. The little monad's destruction, important, no doubt, to itself, would be as nothing in the forest. And this is only a faint, a very faint, comparison to what would be the apparent result in case our earthly dwelling place were swept from the universe — it would be naught but the disappearance of a little speck from the field of created things which the hand of Omnipotence has so profusely thrown around Him. Is then space infinite? Is space then a circle whose centre is everywhere and whose circumference is nowhere? Out in yonder vault see that millionfold world which we call the sun, with its retinue of visible planets and its invisible retinue of its more than 500 asteroids. Out in yonder vault when night falls find a thousand suns similarly attended—with telescope of ordinary power thousands more; with the Lick telescope millions more; with the Yerkes telescope billions more. Is this the end? What astronomer for one moment imagines that another enlargement of the great object glass would show our vision to be already hard up against the frontiers of nature? Where is the verge of the universe? Who would undertake the roll call of its orbs? Who dares to say that he could count through the grand total of its firmaments even though he should count a thousand years?

> "How distant some of these nocturnal suns
> So distant (says the sage) 'twere not absurd
> To doubt if beams set out at Nature's birth
> Are yet arrived at this so foreign World
> Tho' nothing half so rapid as their flight."

Witness the wild dream of Richter, the German poet. It becomes a sort of dreadful, sublime reality.

"God called up from dreams a man into the vestibule of heaven, saying, 'Come thou hither, and see the glory of my house.' And to the servants that stood around His throne He said, 'Take him, and undress him from his robes of flesh; cleanse his vision, and put a new breath into his nostrils; only touch not with any change his human heart — the heart that fears and hopes and trembles.' It was done and with a mighty angel for his guide, the man stood ready for his infinite voyage; and from the terraces of heaven, without sound of farewell, at once they wheeled away into endless space. Sometimes with the solemn flight of angel wing they fled through Saharas of darkness, through wildernesses of death, that divided the worlds of life; sometimes they swept over frontiers that were quickening under prophetic motions from God. Then, from a distance that is counted only in heaven, light dawned for a time through a sleepy flame; by unutterable pace the light swept to him, they by unutterable pace to the light. In a moment the rushing of planets was upon them; in a moment the blazing of suns was around them.

"Then came eternities of twilight, that revealed, but were not revealed. On the right hand and on the left towered mighty constellations, that by self-repetitions and answers from afar, that by counter positions, built up triumphal gates, whose architraves, whose archways — horizontal, upright — rested, rose — at altitude by spans — that seemed ghostly from infinitude. Without measure were the architraves, past numbers were the archways, beyond memory the gates. Within were stairs that scaled the eternities below; above was below — below was above, to the man stripped of gravitating body; depth was swallowed up in height unsurmountable, height was swallowed up in depth unfathomable. Suddenly as thus they rode from infinite to infinite, suddenly, as thus they tilted over abysmal worlds, a mighty cry arose — that systems more mysterious, that worlds more billowy, — other heights and other depths — were coming, were nearing, were at hand.

"Then the man sighed, and stopped, shuddered, and wept.

His overladened heart uttered itself in tears; and he said — 'Angel, I will go no farther. For the spirit of man acheth with this infinity. Insufferable is the glory of God. Let me lie down in the grave and hide me from the persecution of the infinite; for end, I see there is none.' And from all the listening stars that shone around issued a choral voice, 'The man speaks truly; end there is none, that ever yet we heard of.' 'End is there none.' The angel solemnly demanded: 'Is there, indeed, no end? — and is this the sorrow that kills thy soul?' But no voice answered, that he might answer himself. Then the angel threw up his glorious hands to the heaven of heavens, saying, 'End is there none to the universe of God. Lo, also there is no beginning.'"

Thus the art of poetry holds out her hand to the muse of astronomy.

But what shall we say as to the art of Architecture? Gentle Urania raises her arm glittering with her diamonds of the night and points to the arching dome poised on nothing and gemmed with starry coronets. She points to the nebulæ and the star clusters and the double stars and the planets, the fiery white suns and the slowly cooling red suns and yellows suns. She points to the variable stars that now lighten and then darken by turns, to the new stars that blaze up and then die away, to the comets with "horrent hair" plunging through space and to the gentle golden rain of the meteors. She points in a word to the whole hurricane of orbs with which space is peopled and then she says to us, —"Whence are they? How have they been formed and moulded?" To this task the intellect of man has bent itself. And from the darkness has come forth light. Laplace about a century ago, propounded his Nebular Theory and has shewn us how from a great fiery mist that filled up the solar system, far past the limits of Neptune's orbit, and by the ordinary operations of the laws of nature set and kept in operation by nature's God, the great nebula slowly shrunk, rings were thrown off, and each ring became a planet, and then the planets threw off in turn smaller rings, and each ring became a moon, and how one planet

Saturn left a ring that did not become an orb, and that the sun is left as the nucleus of the great solar nebula.

Thus we study the architecture of the firmament and we learn how orbs were created and how by cooling down through myriads of years they became fitted for the abode of sentiment beings. Let me add a word that will be in place — the nebular hypothesis is supposed by some to be opposed to revealed religion. But this is not the case. On the contrary it should tend to exalt our ideas of the Creator. As Herbert Spencer says "Creation by manufacture is a much lower thing than creation by evolution. A man can put together a machine, but he cannot make a machine develop itself. That our harmonious universe once existed potentially, as formless diffused matter, and has slowly grown into its present organized state is a far more astonishing fact than would have been its formation after the artificial method vulgarly supposed."

Listen to Tennyson as he sings,—

> "This world was once a fluid haze of light,
> Till toward the centre set the starry tides,
> And eddied into suns, that wheeling
> Cast the planets."

We are thus taken back into the unfathomable ages of past eternity when the spirit of God brooded on the face of the waters and even before the beginning when the world stuff of solar systems and astral systems suffered bitter pangs and by movements over countless ages generated worlds. During the last decade this hypothesis has undergone some modifications, but all reaching and focusing in the great principle of developmental change and evolutionary creation. Whoever mistrusts the guidance of human reason mistrusts the God that created the human intellect, and one can lay down that proposition and yet avoid rationalism.

From the eddying whirls of fiery nebula the sun-stars are wrought that in their turn "wheeling cast their planets." The white sun-star by long gradations descends through all its changes of temperature and color, yellow, red, purple and

then dark, a cold and burned out cinder-world. But this is not the last of it, for the dark star in its ceaseless flight through space may, as Dr. Croll suggests, collide with some other similarly dark body, and thus both colliding worlds are shattered into vapour or vapour mingled with a universe of meteoric fragments, and so a new nebula is created, the matrix of new worlds that will be generated through ages to come. And so the dark star at the end of one evolution becomes the new nebula at the beginning of a new evolution. Forest leaves bud and bloom and fade and fall, and by their decay chemical elements are released to unite with and form new forest leaves, and thus the world of forest life is constantly renewed. So too, the architecture of creation goes on. The orbs of heaven bud and bloom and fade and fall, and in the icy darkness of their death bring into being new worlds, and so nature ages but never grows aged.

> "Say at what point of space Jehovah dropped
> His slackened line and laid his balance by;
> Weighed worlds are measured infinite no more,
> Where rears His terminating pillar high
> Its extra mandame head? and says to gods
> In characters illustrious as the sun
> 'I stand the plan's proud period, I pronounce
> The work accomplished, the creation closed.'"

What has the muse of astronomy to say to the art of Sculpture? There is a boundless variety in the forms of nature's products and those in the firmament are no exception. The Great Sculptor has fashioned the stars for the most part in a rounded form, but there are certain aggregations of world matter which display a great diversity of form and structure. Scattered or rather arranged over the sky by thousands are these bright, misty spots called nebulæ, which no telescope power has been able yet to resolve into stars. Many of them doubtless are astral systems in process of formation, worlds being born, planets in their juvenility to yet emerge into the full rights and privileges of planethood. Many of them consist of stars so packed together by unspeakable distance and local neighborhood that all individuality of impression on the eye is lost. They are found in great

variety of singular and beautiful forms, sometimes perfectly round, sometimes oval, sometimes lens-shaped, sometimes ring shaped and even consisting of a series of concentric rings. Let us consider the great Nebula in Orion. It appears as an indefinite star. Through a small telescope it loses its aspect as a star and becomes a sort of diffused mist. Through a larger telescope it develops into a strange weird fantastic cloud with long arms stretching out into the infinite darkness of space, like some huge celestial octopus clutching for something in vacuity, and yet reaching nothing. Again let us suppose we look at this piece of nebulous sculpture through a telescope of higher power still, and we find no trace of a star. The nebula defies our highest and most ingenious optical power. Will the time ever come when these misty clouds of fleecy light will ever burst into a blaze of distinct stars, when the astronomer will pierce the glowing veil, and the million eyes of this great Orion universe will look into his, and at last the eager search of man be rewarded? This light has been flying ten millions of miles a minute for 60,000 years to deliver the message that Orion holds in his mighty sword-handle, this aggregation of fiery infinitudes.

But this is only one piece of sculpture that the heavens show unto us. There are many others. There is the ring or perforated nebula of Lyra; the elliptic annular cluster of Leo; the Crab cluster in Taurus; Sobieski's Crown; the Ship nebula Argo; the spiral nebula in the Hunting Dogs; the matchless spiral nebula in Virgo. And these nebulæ — circular, annular, oval, lenticular, conical, spiral, snake-like, looped — are yet in the Great Sculptor's hand and through countless æons change their shape. But it takes a thousand years for the Divine Artist to lift His finger.

But what has the art of Music, "the sacred tongue of God" with all her charms and chimes to say to astronomy? We know that the vibrations of air between certain limits of rapidity produce sound; that the vibrations of the ether, that unsubstantialessence that fills all space, produce the sensation of light. There are vibrations of air so rapid which produce notes so high

that they are not heard by the human ear, and thus the ancients had a quaint conceit that the vibrations caused by the swift motions of the heavenly bodies produced musical notes which varied in their quality and cadence as the motion of the orbs varied, and this phenomenon became known to our language as the "music of the spheres." Hear Shakespeare express his thought :—

> "There's not the smallest orb which thou beholdest
> But in his motion like an angel sings,
> Still quiring to the young eyed cherubim
> Such harmony is in immortal souls,
> But while this muddy vesture of decay
> Doth grossly close it in we cannot hear it."

And thus it is that we are not attuned to such harmony. We strain in vain our ears to hear the chorus of the stars. Mendelssohn has written for us "Songs without words" and on the roll of the firmament we have music without sound, an oratorio of the skies. Profound silence impresses us with conceptions of overwhelming power. The machinery of the firmament moves so smoothly and regularly with a silence more musical than any song, and with a majesty that speaks plainly of great power without effort,

> "And wheresoever in this rich creation
> Sweet music breathes — in wave or bird or soul —
> 'Tis but the fruit and far reverberation
> Of that great tune to which the planets roll."

As architectnre is music carved in stone, so astronomy bids us listen to music glittering in the sky.

We have spoken of poetry, architecture, sculpture and music and what can now be said of the art of Painting. Surely the art of color has something sympathetic and illustrative in the objects of astronomical research. The sun is the source of all light and of all color, and, therefore, the source of all artistic work and painters' skill. Let a beam of white light pass through a prism, and violet, indigo, blue, green, yellow, orange and red flash upon the screen. Examine this spectrum as it is called by the

spectroscope, and we see these wonderful Fraunhoffer lines by which can be discovered the elements which compose sun and star from which the light streams. And as Murillo, Titian, Reynolds or Almatadema unconsciously impresses his individual character upon the canvass, so each nebula or star records in its spectrum its characteristic elements by the peculiar light or dark lines that there are flung. Different in detail, but yet bearing such resemblances that prove the whole universe so far as yet examined to be akin. Without the witchery of color life would be a dull thing and full of melancholy, and so too without the variety which the heavens display they would be robbed of more than half their charm. The Divine Artist has used his palette and decorated the brow of night with many a tint and variegated glory,

"Numerous as glittering gems of morning dew."

Time forbids me from displaying the whole art gallery of the sky. I have only a place for a few from the myriad catalogue. They are the work of the Ancient of Days. Let us look at a cluster found in the constellation Hercules. It is famous among astronomers as being the grandest object of its class in the whole heavens. When Sir William Herschell saw it for the first time through his great reflector it almost made him leap with mingled astonishment and delight. No person ever sees it for the first time through a large telescope without a shout of wonder. Certainly it is an object of wonderful glory,—that golden shield of packed suns. Like the haft of King Arthur's sword "Excalibur" it twinkles with diamond sparks "myriads of topaz lights and jacinth work of subtlest jewellery." Shall we call it the ægis of immortal Jove? Call it rather the flaming buckler of the Creator hung out for a sign on heaven's blue firmament, to proclaim the mighty attributes that belong to Him.

Let me say a word or two of the many colored suns and the binary or double star systems. We are charmed with the variegated flowers of our gardens of earth, but He who makes the

fields blush with flowers under the warm kisses of the sun has planted His wider gardens of space with colored stars. Our sun is a yellow sun — that is prosaic. Look at a system in Andromeda. The large central sun is orange, the small one which gravitates near it is emerald green. A large and magnificent orange sun in the zenith of some planet, then from the east a bright emerald sun rising, whose beams mingle with the orange beams of its brother makes a yellow day. In Hercules we have two suns, red and green. In Berenice's Hair one pale red, the other a clear green. In Cassiopeia a red and a green sun, a fresh series of soft and charming shades. Certain planetary universes lighted up by two suns have all the series of colors included under blue and the brilliant shades of gold and purple which throw so much beauty on those worlds are here unknown.

What a variety of light and shade must exist in a world with a blue sun and a yellow sun, giving sky and meadow a green shade, or on another with an indigo sun in the east and a green sun in the west making all things blue. Or, indeed, it may be that a green sun is monarch of their day, and when it sets, immedately then the dainty fingers of a blue sun paints their firmament with azure to be in turn effaced, and again the emerald reigns supreme. With what wondrous beauty must the worlds which lie in far off universes be clothed.

The invisible planets that are poised near these double suns, are too, probably accompanied by many moons. What is the aspect of these moons lighted by many suns? Thou art very beautiful O night of earth, when Diana "rising in clouded majesty at length unveils her peerless light, and o'er the dark her silver mantle throws." Thus thou dost awaken Milton's song and poets' dreams. But what art thou beside nights illuminated by moons, which reflect the light from many colored suns? We have, indeed, in our own firmament wondrous diversities of color, but what heavenly jewellery is there in other firmaments? And what are the eclipses of the suns on other worlds? Here is a planetary system with a blue sun and a yellow sun. If the blue sun be centrally eclipsed by a moon not large enough to make a

total eclipse, and the yellow sun were below the horizon there would then be a yellow intervening moon surrounded by a rim of blue sun. If the blue sun be totally eclipsed and the yellow sun were above the horizon, then the eclipsing moon would appear as a white circular cloud lighted by a yellow sun. One sun might eclipse the other, causing a blue ring round a yellow centre or a yellow ring round a blue centre producing a green effect.

But we must halt. Nature's treasuries are inexhaustible. Human eyes may contemplate these wonders each day, and yet may never from familiarity appreciate the picturesque value of their abode. What manner of beings occupy these distant spheres? The human race here with all its proud attributes may after all be but a link in the chain. Man is merely earth's highest production up to date. I like Tennyson's philosophy — hearken to it,—

> "This truth within thy mind rehearse,
> That in a boundless universe
> Is boundless better, boundless worse.
> Think you this mould of hopes and fears
> Could find no statelier than his peers,
> In yonder hundred million spheres."

The plan of my address, however, reaches far forward and I see yet more and more opening up — far too much for this occasion. I will be content if I have managed to suggest to any students of art some interest in the great science of astronomy. Here I must end. It is said that Corregio after standing a long time in silent meditation before his canvass, upon which was painted the Nativity, now in the Dresden Gallery, with hands crossed meekly on his breast and head bent reverently low, turned away saying "May God forgive me that I did not do it better!"

I turn back over these pages and feel too, like that artist, but for a far, far stronger reason. We all have our ideals. Our reach is higher than our grasp. We always seek to rise higher than we are, to attain to what we have not, and mayhap to what

we cannot have. It is so in art, it is so in science, it is so in literature, it is so in the limitless pursuits of life.

> " I wonder if ever a song was sung,
> But the singer's heart sang sweeter ;
> I wonder if ever a rhyme was sung,
> But the thoughts surpassed the metre ;
> I wonder if ever a sculptor wrought
> Till the grey stone echoed his ardent thought ;
> Or if ever a painter, with light and shade,
> The dream of his inmost soul portrayed."

MEETINGS OF THE SOCIETY

At Hamilton

May 13.—Our Centre has sustained a severe loss in the death of our treasurer, A. T. Neill, Esq., who passed away suddenly on Thursday, May 12.

Mr. Wm. Bruce, 1st vice-president, who had for years been an intimate friend made the following motion : — In view of the great loss we have sustained by the sudden death of our worthy treasurer, A. T. Neill, Esq., our friend and associate, and the still heavier loss sustained by those who were nearest and dearest to him, be it resolved

That it is only a just tribute to the memory of the departed to say that in deeply regretting his removal from our Society to a higher sphere of existence, we mourn for one who was in every way worthy of our highest regard and esteem as a manly, upright, honest, intellectual, Christian gentleman ;

That we sincerely condole with the family of the deceased on the severe dispensation with which it has pleased Divine Providence to afflict them, and commend them for consolation to Him who orders all things for the best and whose chastisements are meant in mercy ;

That this heartfelt testimonial of our sincere sympathy and sorrow be forwarded to the family of our departed friend by the Secretary of the Royal Astronomical Society, Hamilton Centre.

In seconding this resolution Colonel Grant referred feelingly to his long and pleasant relations with the deceased.

The motion was carried unanimously.

A paper entitled "Some Interesting Binary Stars" was then read by the secretary in the absence of the author, Mr. J. Miller Barr, of St. Catharines. T. H. W.

[The above report was inadvertently omitted from the last issue.--Ed.]

NOTES FROM THE DOMINION OBSERVATORY

Astrophysics

[These Notes were received to late for the last issue of the Journal].

Weather conditions during the time Halley's Comet was at its brightest were extremely unfavorable. While visible to the unaided eye in the eastern sky it was either so obscured by clouds or by haze near the horizon that no very successful photographs were secured. Conditions improved somewhat after May 18th, but even then nothing of value was obtained until May 28th when the comet had much diminished in brightness. Photographs were made whenever possible with the Brashear 8-inch stellar camera and with a Zeiss Tessar objective of 12 inches focus, f 3·5, mentioned in previous notes. With the latter, which gives excellent definition, although as is to be expected the illumination appreciably diminishes towards the margins of the plate, upwards of 20° of tail was secured.

Both of these cameras are attached to the equatorial and guiding is usually effected by the micrometer. This can be done nearly as easily by keeping the nucleus central upon the slit of the single prism spectrograph. Consequently, although it was not expected much would be obtained, the latter instrument was attached on two or three nights and exposures with a wide slit made upon Lumiere Sigma and Wratten and Wainwright Panchromatic plates. No impression of the comet spectrum was however obtained.

Orbits for four spectroscopic binary stars are approaching

completion although in two cases some further plates are required. At this time it may be of value to give the approximate periods.

Star	App. Period	Observer
γ Orionis	131·4 days	W. E. Harper
7 Camelop	3·885	W. E. Harper
93 Leonis	71·7	J. B. Cannon
ω Ursæ Majoris	15·8	T. H. Parker

J. S. P.

In this JOURNAL Vol. III., page 377, was given a determination of the orbit of ϵ Herculis from sixty plates of 1908 and sixty of 1909. A previous preliminary determination using some plates of 1907, with those of 1908, gave slightly different values for some of the elements. The period determined for the 1908-09 series was 4·0235 days, whereas the former determination was 4·0126 days and it was assumed that this element was a varying quantity and a statement to that effect was made.

Quite recently Mr. Robert H. Baker, of the Allegheny Observatory, drew the writer's attention to the possibility of a mistake in the dates of the 1907 plates, as their observations of that year were all satisfied by the period 4·0235 days. On looking the matter up it was found that the Julian Dates, as tabulated for the plates, were in each case one day more than they should have been and consequently the period of 4·0126 days was in error. Just how the mistake occurred is not known ; the writer accepts full responsibility for it however, and is much indebted to Mr. Baker for his communication in regard to the matter.

Making the necessary correction, the 1907 observations were now found to agree well with the elements from the 1908-09 determination. There seemed to be little or no necessity for making any changes in them but for satisfaction a new determination was made. Four of the twenty-three plates of 1907 were, on re-examination, rejected owing to their poor quality and the remaining nineteen were used with the other one hundred and twenty in a least square solution. The changes in the values are as follows :—

Elements	1908-09 Plates	All Plates
e	·074	·071
ω	267°·97	269°·23
K	52·75 km.	52·60 km.
T	J. D. 2417725·113	2417725·130
A	52·61 km.	52·47 km.
B	52·89 km.	52·73 km.
$a \sin i$	2,907,000 km.	2,903,000 km.

The other values remain as before but in the case of these elements the new values, though differing so slightly from the former, should replace them.

W. E. H.

The Seismograph—Bosch Photographic, 200 Grammes

The following earthquakes have been recorded since the last notes were sent :—

1910		N–S Component	E–W Component
June 14		h m s	h m s
	1st P. T.	. . .	19 46 00 G.M.T
	2nd P. T.	. . .	19 51 46
	P.P. (?)	. . .	19 54
	P.P.	. . .	19 55 40
	End	. . .	20 26
	Distance 4000 km.		
June 16			
	1st P. T. (?)	. . .	6 50 00
	2nd P. T.	. . .	7 00 50
	P. P.	. . .	7 07 40
	Max.	. . .	7 08·5
	End	. . .	9 25
	Distance 5800 km.		
June 25			
	Waves	19 42	19 42
	Long Waves	19 57·0	19 57·5
	End	20 55	20 20

		N–S Component h m s	E–W Component h m s
June 29			
	1st P. T. (?)	8 29 40	8 29 34
	2nd P. T. (?)	8 36 52	8 37
	P. P.	8 47 13	8 47 34 (?)
	Max.	8 53 40	8 53 32
	End	10 20	10 10
	L. waves by longer arc	11 13	11 14
	Max.	11 47	. . .
	End	13 42	13 25
Distance 5800 km.			
July 2			
	Waves	17 25	17 25
	Long Waves	17 29	17 29
	Max.	17 30 10	17 30 40
	End	17 50	17 43
July 3			
	Waves	9 25 40	9 25 36
	Inset	9 27 31	9 27 28
	Max.	9 28 30	9 28 23
	End	10 00	10 00
July 4			
	Waves	4 51	5 08
	Inset	5 08	. . .
	Long Waves	5 09	5 09
	End	6 03	5 16
July 7			
	1st P. T.	4 51 34	4 51 30
	2nd P. T. (?)	4 56 15	4 56 15
	P. P.	4 58 31	4 58 40
	Max.	4 59 20	4 59 24
	End	6 02	5 45
Distance 3000 km.			
July 7			
	Waves	8 35 16	. . .
	Inset	8 39 22	. . .
	Long waves emerge	9 34	9 34
	End	10 20	10 12
July 17			
	Waves	8 14	8 14
	End	8 22	8 22

		N–S Component h m s	E–W Component h m s
July 17			
	1st P. T.	10 07 15	10 07 12
	2nd P. T.	10 13 00	10 13 00
	P. P.	. . .	. . .
	Max.	10 20 20	10 20 16
	End	10 55	10 57
Distance 4000 km.			
July 20			
	1st P. T. (?)	3 47 19	. . .
	Inset	3 56 08	3 56 08
	Inset	. . .	3 56 52
	Long Waves	4 01	. . .
	End	4 25	4 16
July 29			
	Waves	. . .	10 48
	Long Waves	. . .	10 59 14
	End	. . .	12 35
August 5			
	1st P. T.	1 38 30	1 38 30
	2nd P. T.	1 44 20	1 44 11
	P. P.	1 48	1 49·4
	Max.	1 51·7	1 54
	End	3 25	3 18
	L. waves by longer arc	4 08	. . .
Distance 3900 km.			

MAGNETIC OBSERVATIONS

Mr. C. A. French is observing along the Canadian Pacific Railway from Chapleau to Regina, covering about 21° of longitude. The stations are located at an average distance of 25 miles; and Mr. J. W. Menzies is covering similarly the western peninsula of Ontario. The instruments, magnetmeter and dip circle, are compared at the base-station—Agincourt—before and after the season's work.

OTTO KLOTZ.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
Aug. 10, 1910.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

June, 1910

Temperature—The mean temperature was above the average from the Rocky Mountains to the Georgian Bay and also very locally in the Maritime Provinces; elsewhere in Canada the normal was not reached. Over the Western Provinces positive departures from normal were from 1° to 6°. In British Columbia negative differences were from 1° to 6°, while in the Eastern Provinces they were from 1° to 3°.

The latter half of the month was exceptionally warm in all districts, and especially so in the Western Provinces were maximal temperatures were generally much in excess of 90°.

Precipitation—There was a great lack of precipitation throughout Canada during June, except in the Maritime Provinces and very locally in South Eastern Saskatchewan, where an amount in excess of the average was recorded.

The amount of rainfall in the Western Provinces and Ontario was, in most localities, considerably less than half the usual quantity.

July, 1910

Temperature—The mean temperature of July was a little above normal over the larger part of the Dominion, but in northern and western British Columbia, there was a negative departure, which in some localities was as much as 3° and 5°; and in some districts of Ontario, including the Ottawa Valley, the temperature was between 1° and 2° in defect of the normal. Very high temperatures were recorded in all the Provinces and in the

Temperatures for June and July

Station	June		July	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	85	31		
British Columbia				
Atlin	74	30	77	34
Agassiz	91	42		
Barkerville	75	26	74	34
Kamloops	97	42	95	46
New Westminster	81	40	88	44
Port Simpson	62	39		
Vancouver	75	41		
Victoria	76	41	87	45
Western Provinces				
Battleford	96	28	95	42
Broadview	106	24	98	39
Calgary	87	30	92	35
Carman	103	38	100	47
Edmonton	94	30	87	38
Medicine Hat	102	30	103	42
Minnedosa	99	30	104	40
Moose Jaw	98	28	96	41
Oak Bank	95	30	91	45
Portage la Prairie	100	32	100	47
Prince Albert	90	25	87	39
Qu'Appelle	93	27	88	41
Regina	92	26	92	40
Swift Current	98	30	98	42
Winnipeg	99	31	96	47
Ontario				
Agincourt	90	38	97	49
Aurora	92	31	94	42
Bancroft	87	29	90	42
Barrie	89	35		
Beatrice	84	32	87	43
Birnam	88	37	92	48
Bloomfield	86	36	91	52
Brantford	92	37	95	43
Bruce Mines	93	33	90	43
Chatham	96	33	97	50
Clinton	85	33	92	45
Cottam	92	30	95	47
East Toronto	92	39	90	51
Gravenhurst	87	29	89	43
Guelph				
Haliburton	90	30	93	40
Hamilton	92	43	95	51
Huntsville				
Kenora	99	30		
Kinmount	87	30	89	39
Kingston	79	38	83	52
Lakefield				
London	92	34	97	47
Lucknow	84	31	87	44
Madoc	90	29	91	40
Meaford	85	37		
Midland	87	45	90	56
North Gower	90	31	93	43
Otonabee	89	38	90	50
Ottawa	86	35	88	52
Owen Sound			93	43
Paris	89	36	93	46
Parry Sound	85	35	95	49
Peterboro'	87	39	91	49
Point Clark				
Port Arthur	97	32	87	45
Port Burwell	87	39	84	51
Port Dover	85	36	90	50
Port Hope				
Port Stanley	89	36	88	49
Ronville	86	36	89	44
Sarnia				
Southampton	82	35	85	44
Stonecliffe	84	27		
Stony Creek	91	36	95	48
Stratford	87	33	91	47
Toronto	93	41	93	51
Uxbridge	88	34	95	40
Wallaceburg	93	38	93	48
Welland	87	38	90	52
White River	90	28	86	32
Quebec				
Brome	82	29	85	41
Father Point	68	29	78	41
Montreal	83	37	87	54
Quebec	81	32	90	51
Sherbrooke	83	32	91	49
Maritime Provinces				
Charlottetown	76	34	84	51
Chatham	80	35	92	46
Dalhousie	75	32	90	47
Fredericton	84	39	89	43
Halifax	81	36	86	48
Moncton	79	33	89	47
St. John	76	39	77	50
St. Stephen				
Summerside				
Sussex	81	29	85	47
Sydney	76	31	86	45
Yarmouth	69	31	75	48

West, thermometer readings in excess of 100° occurred in many districts, chiefly between the 12th and 17th, during which period occurred the only very pronounced heat spell of the month.

Precipitation—The precipitation recorded in Canada during July was less than average in most districts. This was particularly the case in southern parts of the Western Provinces, where the fall was a very small percentage of the normal.

In Quebec and the Maritime Provinces, the total fall was almost generally in excess of the normal, and this was also the case locally in Ontario, more especially in counties contiguous to the shores of Lakes Ontario and Erie.

R. F. S.

Earthquake Records by Milne's Seismograph

TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1910		P.T Comm		L.W. Comm.		Max.		End.		Max. Amp.	Durat.		Remarks
			h	m	h	m	h	m	h	m	mm.	h	m	
919	June	1	6	16·5					8	43·0	0·10	2	26·5	
920	"	9	21	56·5					22	06·0	0·10	0	9·5	Doubtful as to being seismic
921	"	14	19	51·5					20	30·0	0·25	0	38·5	
922	"	16	4	50·0					4	58·0	0·10	0	8·0	
923	"	16	6	50·8			7	2·0	9	36·0	2 00	2	45·2	Extended increase activity 2h 51m and 3h 57m.
924	"	17	17	23·0							0·20		?	
925	"	24	14	00·0										
926	"	25	20	7·8	20	11·7	20	13·1	20	17·5	0·10	0	9·7	
927	"	29	8	43·7	8	53·4	8	55·9	{ 9 32·1? 9 56·4		1·50	1	12·7	
928	"	29	11	15·1			11	22·0	11	34 6	0·10	0	19·5	
929	"	29	11	38·6	11	44·8	12	18·1	12	49·0	1·00	1	10·4	
930	"	29	12	52·9	12	56·9	12	57·9	13	9·9	0·50	0	17·0	
931	"	29	14	47·5			14	48·0						
932	"	29	15	21·9	15	28·2?	15	53·6	16	29·2	0·40	1	7·3	
933	July	3	9	27.2					9	36·0	0·10	0	8·8	
934	"	7	4	No.P.Ts.	4	58·9	4	59·3	5	46·7	1·00	0	47·8	Skagway
935	"	10	15	17·6			15	25·0	15	51·4	0·40	0	33·8	
936	"	29	11	26·9					12	0·0?	0·10	0	33·1?	

Vib. 14·8 seconds. 1 mm. = 0″·64

VICTORIA, B. C.

E. B. Reed. Superintendent.

No.	Date 1909		P.T. Comm.		L.W. Comm.		Max.		End		Max. Amp.	Durat.		Remarks
			h	m	h	m	h	m	h	m	mm.	h	m	
953	June	1	6	20·9					8	0·0?	0·25	1	39·1?	
954	"	7	19	14·2					19	22·0	0·10	0	7·8	
955	"	16	4	59·0					5	6·0	0·10	0	7·0	
956	"	16	6	43 0	6	54·0	6	56·0	9	17·0	2·00	2	34·0	Small well defined.
957	"	17	17	2·0					18	5·0	0·20	1	3·0	Prolonged thickenings
958	"	21	14	1·0					14	4·0	0·10	0	3·0	
959	"	24	14	15·0					14	27·0	0·10	0	12·0	
960	"	25	20	1·0					20	4·0	0·05	0	3·0	
961	"	27	5	50·0					5	51·0	0·05	0	1·0	
962	"	29	8	26·8			8	36·8	9	34·8	0·50	1	8·0	
963	"	29	11	11·8					11	17·8	0·05	0	6·0	
964	"	29	11	27·0					11	56·5	0·05	0	29·5	
965	"	29	14	38·0					14	39·0	0·05	0	1·0	
966	July	3	9	6·0			9	7·8	9	27·6?	1·00	0	21·6?	
967	"	7	4	40·2	{ 4 41·0 4 42·2 4 43·1		4	44·1	5	32·0?	2·50	0	51·8?	Skagway.
968	"	10	15	29·9			15	42·2	15	47·8?	0·20	0	17·9?	
969	"	17	10	17·2					10	23·0	0·10	0	5·8	
970	"	29	10	50·3					11	28·8	0·05	0	38·5	

Vib. 15 seconds. 1 mm. = 0″·76.

J. V.

ASTRONOMICAL NOTES

PHOTOGRAPHS OF AURORÆ—As an abstract from the *Comptes rendus*, we have received from the author, M. Carl Stormer, an interesting note on a photographic method of determining the altitudes of auroræ. The difficulty in obtaining such photographs is, of course, the extreme feebleness and the motion of the light, but, by using a cinematograph lens of 25 mm. diameter and 50 mm. focal length, in conjunction with Lumière's "violet" plates, M. Störmer succeeded in obtaining measurable images, some of which are reproduced in his note. By choosing two stations 4·3 km. apart and arranging for simultaneous exposures, data for determining the altitude were secured. The four sets of photographs reproduced represent different forms of auroræ seen during March, and also show recognisable stars, so that the parallax of definite points is easily calculated. The heights determined are 166 km., between 50 and 60 km., 190 km. and 120 km. respectively.—*Nature*, No. 2125.

THE GENESIS OF VARIOUS LUNAR FEATURES—M. Puiseux discusses the probable origins of the circles and of the angular outlines of lunar crevasses shown in the polar regions of the moon on the concluding sheets of the great photographic atlas of the moon published by the Paris Observatory. He points out that many of the circles appear in chains, of two or more, parallel or perpendicular to the meridian. Where two of these circles intersect, the point of junction is marked by a small crater or a considerable elevation, and M. Puiseux believes that this is evidence against Faye's theory that the *bourrelets* were formed by

repeated periodic overflowings which filled in the circle. Such differences of level as are now revealed would be incompatible with this theory. On the same plate (lxvi.) is seen a number of circles aligned on, or across, a meridian, and joined by a high, narrow ridge, and M. Puiseux considers that these are evidences against the meteoric bombardment theory.

Near the northern pole the geometrical contours of circles are exceptional, and angular features predominate The ridges here are found to be in echelon, and M. Puiseux considers that the sharp angles were formed where previous ejecta prevented the eruptions from following the general line of weakness to which, however, the subsequent eruptions returned, thus producing the echelon form.—*Nature*, No. 2126.

Spiral Nebulæ—Referring to some photographs taken with the 60-inch reflecting telescope at Mount Wilson Solar Observatory, Professor G. W. Ritchey states in *Monthly Notices* R. A. S., No. 8, 1910:—It seems to me that the 60-inch photographs throw much new light on the subject of the spiral nebulæ. They show, in the case of all the spirals which I have photographed, that the branches are apparently composed both of smooth nebulous material and also of soft star-like condensations or nebulous stars, as if the spiral nebulæ were actually condensing into stars. In Messier 33 Trianguli I have counted over 2400 of these nebulous stars; in Messier 101 Ursæ Majoris I have counted over 1000; in Messier 81 Ursæ Majoris approximately 400; in Messier 51 Canum Venaticorum about 250; in Messier 63 Canum Venaticorum, about 200.

Messier 64 Comæ Berenicis is unlike all of those above named in that the 40 or 50 nebulous stars shown in it are near the centre of the nebula, while the outer branches are apparently smooth, without condensations. In Messier 33 and Messier 101 the nebulous stars are frequently massed in great branches. The Great Andromeda Nebula is more like Messier 81; in both, the central parts apparently consist of smooth material with compli-

cated systems of dark rifts, while the outer branches contain great numbers of nebulous stars.

LIGHT PRESSURE.—The forces due to light are so small, and the disturbances due to convection are relatively so great, that we cannot expect to find any effects due to light pressure here on the surface of the earth surrounded by a dense atmosphere. But out in interplanetary space, where the vacuum must be far higher than anything to which we can attain, the light forces may have uninterrupted play, and in the course of ages they may produce great effects; but even then only small bodies will be seriously affected. Take, for instance, a sphere; the pressure of sunlight upon it varies as the square of the radius, and the mass as the cube of the radius. Thus the acceleration produced is inversely as the radius for spheres of the same density. The whole pressure of sunlight upon the earth is only a forty-billionth part of the sun's gravitative pull. If we reduce the radius the pressure becomes more important in proportion, and on a sphere of one forty-billionth of the radius of the earth — or 16×10^{-6} cms. radius — and of the earth's density, if diffraction did not come into play, the pressure of sunlight would balance gravitation. Still smaller spheres would be pushed away.

But in the case of bodies somewhat larger than those in which gravitation is neutralised by light pressure. If a sphere 1 cm. in diameter, and of the density of the earth, is moving round the sun at a distance equal to that of the earth, it will fall in about one mile in the first year. If it continues to describe a nearly circular spiral, it will fall in less and less each revolution, but the revolutions take less and less time, and in equal times it will fall in more and more. Such a sphere will reach the sun in something of the order of 45,000,000 years. But the rate of falling in is inversely as the radius, so that a sphere 1/1000 cm. in diameter will fall in 1000 miles in the first year, and will reach the sun in 45,000 years.

There is no doubt that there are such bodies in our system.

We have clear evidence of their existence when they perish as shooting stars in our atmosphere. Also there seems no way to avoid the conclusion that they are all spiralling in to the sun and will ultimately reach him unless their career is cut short by some intervening planet. How, then, are we to account for their existence in our system to-day? Whatever limit we may assign to the age of the earth as a habitable globe, we must assign to the sun some vast number of millions of years, vast enough to have allowed him long ago to draw to himself all the specks of dust in his system. How is the supply renewed? Is interstellar space inhabited by scattered meteorites? Are they brought in by comets which have become disintegrated? And so light pressure raises once more an old and still unsolved problem.—PROFESSOR J. H. POYNTING and DR. GUY BARLOW, *Nature*, No. 2127.

UNDER the presidency of Professor Edward C. Pickering the eleventh annual meeting of the Astronomical and Astrophysical Society of America was held at Harvard College Observatory, Cambridge, Mass., August 17-19. This date was arranged for so that the members might have the opportunity of attending the Fourth Annual Conference of the International Solar Union held at Mount Wilson, California, August 30 to September 6.

PERSEID METEORIC SHOWER, 1910.—The only night really good for witnessing the Perseid shower near its maximum this year was August 10, when the clear state of the sky afforded every facility for securing observations.

I began watching at 9^h p.m., and up to $11^h\,45^m$ p.m. there were fifty-two meteors, so that the hourly rate was nearly twenty, of which about three-fourths were Perseids. The finest specimen appeared at $10^h\,6^m$; it had a long and slowish flight from $328° + 37°$ to $301° + 8°$, and left a bright streak just above the small stars of Delphinus for fifteen seconds. The meteor itself was much more luminous than Venus, and was also observed by Mr. T. K. Jenkins at Nantyglo. From a comparison of the

recorded paths, I find the height 75 to 48 miles over Wiltshire, and the end point near Blandford, Dorset.

The velocity was decidedly slower than that of the ordinary Perseid, its observed speed being 27 miles per second.

I saw brilliant Perseids also at 11.34 and 11.46, the former shortening towards α Andromedæ and the latter just under Polaris, and at 11.34½ there was a beautiful slow-moving Draconid falling from 303½° + 33° to 311° + 19½°. Its pear-shaped nucleus threw off a tail of yellow sparks as it sailed down the sky.

I think the display of August 10 was better than it was last year, and gave promise of a pretty abundant shower on August 11 and 12, but I cannot speak as to its actual character, the firmament being cloudy on those dates at Bristol.

There were a few breaks in the clouds on August 12, and I happened to notice a fine meteor at $11^h\ 49^m$ shooting upwards from 355° + 40° to 338½° + 50°. It was as bright as Jupiter at least, and left a train, but it quickly disappeared. The meteor was not a Perseid, but apparently belonged to a shower with radiant lying eastward of α Andromedæ, or at 9° + 27°. The meteor was also seen by Mr. G. Powell at Aberdare, and I find its height 89 to 53 miles. It was nearly over Bath at end point. Velocity 40 miles per second, and certainly more rapid than the Perseid alluded to above, though it should have been the swifter of the pair.

Several observers have written me describing the Perseid shower as fairly rich on August 10, though the maximum was not due until the morning of, or night following, August 12. Some large meteors were also recorded on August 5, which was a very clear night, and the Perseid display was in pretty strong evidence even at that early date.—W. F. Denning, *Nature*, No. 2129.

Argentine National Observatory — Dr. Sebastian Albrecht, has been elected to the position of Astronomer at the National Observatory of the Argentine Republic at Cordoba, of which observatory Mr. C. D. Perrine was chosen director a year

ago. Dr. Albrecht has been connected with the Lick Observatory for the past seven years and has earned a reputation as a skillful and accurate observer and an able astronomer. He was married on June 29 to Miss Violet E. Standen, Secretary of Lick Observatory. The wedding was celebrated at the home of Director Campbell, and is the first event of the kind which has occurred on Mt. Hamilton. Dr. Albrecht and his bride sailed early in July for their new home. — *Popular Astronomy*, No. 7, 1910.

THE SPIRAL NEBULA M51 (CANUM VENATICORUM) —As an extract from the *Rivista di Astronomia* (Turin), we have received a paper in which Madame Dorothea Isaac-Roberts discusses in detail the numerous condensations, spirals, &c., shown on Dr. Roberts's photograph of the spiral nebula M51 Canum Venaticorum. Each feature is described, and the position-angles, distances, &c., are given, so that any future worker may determine, with a minimum of labour, whether or not any variation has taken place since the epoch when Dr. Roberts's photograph was taken. Madame Roberts also shows that the present form indicates a process of evolution which has led, and will probably lead, to the partition of this remarkable object into secondary nebulæ and condensations. — *Nature*, No. 2129.

DR. GALLE.—Johann Gottfried Galle, who was the first to observe the planet Neptune at the request of Leverrier on September 23, 1846, died on July 11th, 1910, at the advanced age of 98 years.

PROFESSOR SCHIAPARELLI—Giovanni Virginio Schiaparelli, the first to observe and systematically map out the faint markings on the planets Mars, Venus and Mercury, and to note that the Perseid meteors are the remains of the wreck of Comet II., 1862, and that the Leonid meteors are the remains of Comet I., 1861, died on July 4, 1910, at the age of 75 years. Schiaparelli in his prime was noted for his exceptionally keen eyesight, but like the great Galileo, some months before his death became totally blind.

J. ELLARD GORE—John Ellard Gore, the versatile and accomplished author of a number of astronomical works that are, doubtless, familiar to the most of the members of this Society, was accidently killed by a street car, in the City of Dublin, on the evening of Monday, July 18 last. Mr. Gore graduated from Trinity College, Dublin, in 1865, was elected a Fellow of the Royal Astronomical Society in 1878. He was also a member of the Royal Irish Academy and an Honorary Fellow of the Royal Astronomical Society of Canada. In his earlier life he was a keen observer of variable stars, of which he formed a catalogue in 1884, but of late years, because of failing eyesight, he has been compelled to devote himself to literary work which has enriched the literature of astronomy of to-day.

STELLAR MOTIONS—*Astrophysical Journal*, Nos. 612 and 614, contains Professor Lewis Boss' "Memoir on Precession and Solar Motion." The investigation depends on the proper motions of more than 5,000 stars distributed with apparent uniformity over the entire sky from pole to pole. Professor Boss has undertaken from these to reduce the position of the solar apex, with corrections to Newcomb's equinox of 1874 and precessions. The equations solved give the position of the Solor Apex :

R. A.	270°·52	± 1°·08 to ± 1·53
Dec. +	34 ·28	± 0 ·90 to ± 1·38

with centennial parallactic drift at 90° from the Solar Apex, of 3″·85.

In reference to this work Professor Turner in the *Observatory*, No. 425, remarks :—

In the May number, reference was made to Boss' Catalogue of 6000 fundamental star places and proper motions, and it was remarked that the discussion of the P.M.'s had led the distinguished investigator to results directly at variance with those of Kapteyn, Eddington, Dyson, and others, as to the existence of two stellar streams, though the details had not yet appeared. As a matter of fact, the first paper on the subject was actually in

type, and the second followed some weeks later. These two remarkable papers create about as sensational a situation as there has ever been in the history of astronomy. The whole of modern stellar observation is under dissection, and two opposite conclusions are drawn. The investigators concerned are all men of profound knowledge and skill; and one school says there are two definite streams of stars, the other (represented by an Athanasius) that there is no trace of duality, but as good evidence of random motions (modified by a few well-marked local disturbances, due to moving clusters) as one could wish. The settling of this matter should be a battle of the giants. Let us get front places if we can: the fate of the universe is at stake.

AT MOUNT WILSON—Professor C. A. Chant, Toronto; Director R. F. Stupart, of the Meteorological Service of Canada and J. S. Plaskett, of the Dominion Observatory, Ottawa, represent the Royal Astronomical Society of Canada at the International Solar Union meeting, in Solar Observatory at Mount Wilson, August 29 to September 6.

NEW COMET—A comet was discovered by Rev. Joel H. Metcalf, of Taunton, Mass., on August 8, in R. A. $16^h\,27^m$; Dec, $+16°\,0'$. Professor Kobold, of Kiel, from three observations calculated its perihelion passage August 30 and its distance from the sun, at that point, at about 180,000 miles.

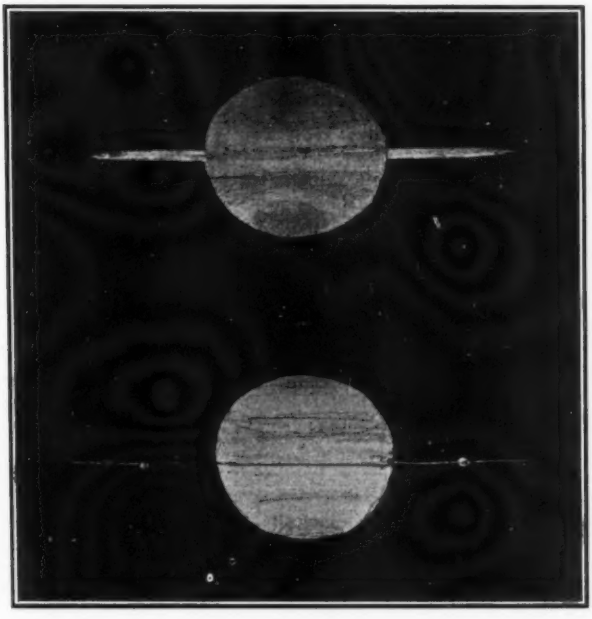
SIDEREAL TIME PIECE.—Rev. Dr. Marsh, Secretary of the Peterboro Centre, has designed a sidereal watch, having a dial numbered from 1 to 24, graduated to minutes and seconds and with the simple train, instead of quadruple face wheels. A Toronto firm has had a number of these astronomical time pieces made from this special design.

MEETINGS RESUME IN OCTOBER—The meetings of the Royal Astronomical Society of Canada will be resumed in October at the various Centres. The members will be notified by the Secretaries of the Local Centres in due course—for Toronto, Ottawa, Hamilton, Peterborough and Regina.

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.



SKETCHES OF SATURN,
Made by Andrew Elvins

Upper—Rings slightly widened, knots invisible. Summer, 1892.
Lower—Rings almost invisible showing knots. Autumn, 1892.

KNOTS ON SATURN'S RINGS

In 1907 when Saturn's Rings were turned edge-on, interesting observations were made of "knots" in the plane of the rings.

Mr. Andrew Elvins, the patriarch of the society, brought to me two drawings of Saturn made in the year 1892 (per illustration), on one of which three "knots" are shown. These are representations of the planet as seen in a 3-inch refractor, though Mr. Elvins occasionally had access to a 4-inch refractor and a 12-inch reflector.

Under date July 5, 1910, Mr. Elvins writes :—

"I have just finished reading Professor Lowell's very interesting book 'The Evolution of Worlds.' In one part it refers to the 'knots' on the Rings of Saturn, which were so often observed and referred to a year or two ago. I remember watching the ring disappear on former occasions, and I noticed bright spots in the plane of the ring at the time when it was almost invisible. Some of my drawings show these spots, which I took for satellites, though I wondered how they were always so near the planet. I send you two of these. One shows the ring when somewhat wider, no bright points were then seen.

I hope our members will read 'The Evolution of Worlds.' It examines most of the theories which have been popular in the past, and the arguments frequently appear conclusive to me; though I wait to read Professor See's book, which I hope will be published this month."

THE "CAPTURE" THEORY IN THE EVOLUTION OF A SYSTEM

As is well known Professor See strongly supports the theory that planets and satellites and comets are added to a system through being "captured" by superior bodies. This same view was clearly presented by Mr. Elvins in a letter appearing in *The Astronomical Register* for March, 1869, page 69. The heading of the letter is "Facts and Speculations Relating to Saturn's Rings," and the following extracts from it will be found of interest :—

"Saturn's ring is an anomaly in the solar system; the only object of that kind with which the most powerful telescopes in existence have made us acquainted. It lies in the plane of the planet's equator, and the entire diameter of the outermost ring is more than 150,000 miles. Its appearance when seen from the earth greatly differs; sometimes it shows itself as a ring enclosing the planet; at other times it is seen as a line of light only; in fact, when its edge is turned towards us, none but the most powerful instruments can render it visible. At one time it was thought that this ring was solid and single; that it is in reality composed of several

rings is now certain; and, what is still more strange, these rings really seem to be undergoing change.

Of late, very moderate telescopes have shown us a ring before unnoticed—a transparent one, on the inside of the bright ones before known. Through this ring the body of the planet is visible; but this *crape ring*, as it is has been called, was not seen by Herschel or the astronomers of his day, though they possessed fine instruments, and saw far more difficult objects in his system than that ring. Telescopes which will now show that ring with ease will not show the satellites which he discovered and frequently saw. That he should have overlooked the ring, if it then existed, is truly wonderful; and many think that at that time it was not formed, or that it must be more dense now than it was then. . . . . .

What are those rings? Did they always form a part of Saturn's system, or are they the matter of a foreign body, which has paid old Saturn a visit, and which, when many cycles of centuries shall have passed away, may be looked for in vain? Strange as it may appear, I think it neither impossible nor improbable, that such may be the case. . . . . ."

Referring to former discussions on comets the letter continues :—

"I think I may be able to show that even Saturn's rings may owe their existence to a comet; in fact, *that it is a comet*, seized by the attraction of Saturn, and held in his grasp, encircling him instead of following its former course around the sun."

Further details are given as to the probable manner in which a capture takes place and a suggestion as to why the least dense ring should be nearest Saturn's globe.

C. A. C.

Query

Is it true, that the cultivation of the land in the Canadian North West has appreciably changed the seasons? Are summer frosts and intensely low temperature in winter less frequent than formerly?—F. B. T.

Answer

Extract from a recent paper by the Director of the Meteorological Service :—

"We have seen then that the winds and weather of the Dominion as well as of the other countries are governed by the general circulation of the atmosphere of the globe; to a certain extent, modified by continent and ocean. The air which

passes over any territory to-day is gone to-morrow to other regions, and disturbances which lead to temperature changes and rainfall represent the expenditure of such enormous energy that it is difficult to conceive that tillage and drainage of the soil can change the climate of a country to anything approaching the extent, that persons unfamiliar with weather maps sometimes imagine.

An observing station was established at Winnipeg in 1871; and in 1883 and 1886 stations were established at Minnedosa, Qu'Appelle, Swift Current, Port Arthur, Battleford, Calgary and Edmonton, and from the records obtained from these stations there is no conclusive evidence of any permanent change in the climatic conditions of the west, either as regards precipitation, or the severity of winters. There is just some small reason for belief, however that the plowing up and draining of the land may have a slight effect towards lessening the danger of the summer frost, but evidence in support of this is inconclusive."

PREDICTIONS FOR SEPTEMBER AND OCTOBER

Constellations on the Meridian in September

Cygnus (The Swan) is marked by five stars forming a conspicuous cross in the heavens, which may, without unduly stretching the imagination, be likened to the outline of a flying swan. It is in the Milky Way, which here begins to separate into two streams, and contains telescopic fields of great magnificence. Its brightest star α, sometimes known as Arided or Deneb, crosses the meridian two hours and five minutes after Vega and a few degrees higher, almost exactly in the zenith ; it is between the first and second magnitudes, but has no appreciable parallax or proper motion, being, therefore, at an immense distance, and possibly surpassing Vega or even Sirius in size ; it is approaching us at the rate of about forty miles per second. About 15° east of α there suddenly appeared, in 1876, a Nova of the 3rd magnitude, which later faded irregularly to the 14th magnitude.

Vulpecula (The Fox) and *Sagitta* (The Arrow) are two small constellations immediately south of Cygnus, between it and Aquila. Neither of them contains any bright stars, but as both are traversed by the Galaxy the telescopic fields are good. Vulpecula, in particular, contains one of the prettiest of telescopic objects, the well-known Dumb-Bell Nebula. Sagitta is one of the ancient constellations, but Vulpecula is comparatively modern, having been named by Hevelius about the end of the seventeenth century.

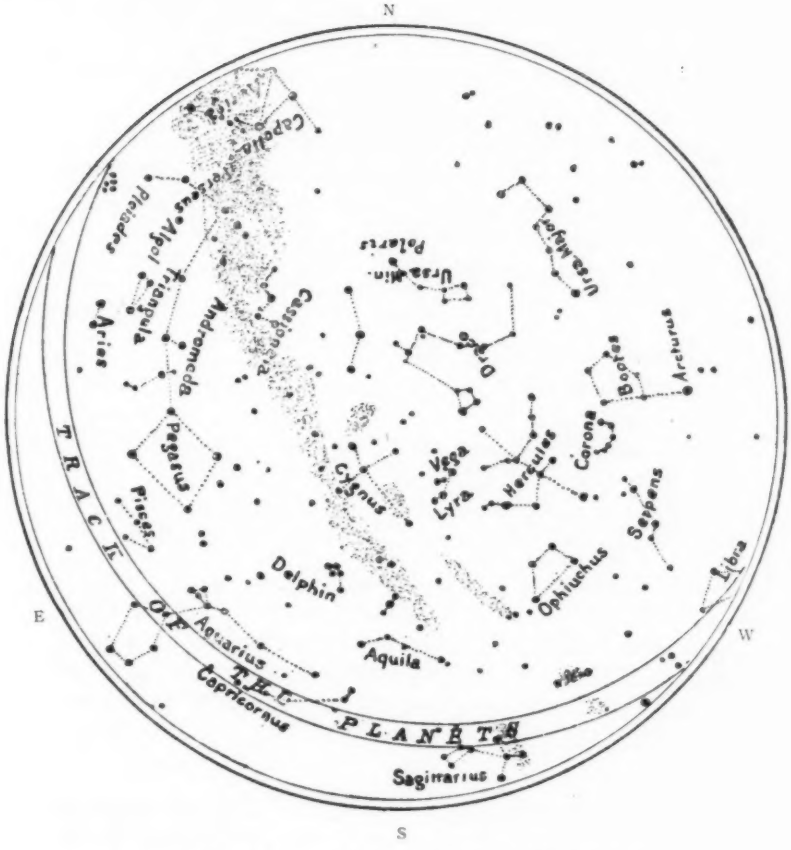
Delphinus (The Dolphin), otherwise known as Job's Coffin, is another small constellation to the immediate north-east of Aquila, containing a little group of five stars of the third magnitude. Two of these bear the not too euphonious names of Sualocin and Rotanev; it has been conjectured that they were derived by reversing the letters in the name (Nicolaus Venator) of an assistant at the Palermo Observatory, in the catalogue emanating from which these stars are so denominated.

Aquila (The Eagle) is on the meridian about nine o'clock at the beginning of September, being then about half way from the horizon to the zenith. It is conspicuously marked by Altair, a fine star of the first magnitude, which crosses the meridian seventy minutes after Vega. Though Aquila is a large constellation it contains only three other moderately bright stars, all of the third magnitude.

Capricornus (The Goat), the tenth sign and eleventh constellation of the zodiac, contains four stars of the third magnitude and four of the fourth. It may be readily recognized by two stars pointing directly to Altair, which pass the meridian twenty-seven minutes after him, about 20° lower; just below them in the same line is a fourth magnitude star; four other stars, the first two of the fourth, the others of the third magnitude, extend in a line almost at right angles to the former towards the east.

Constellations on the Meridian in October

Aquarius (The Waterman), a large and irregularly shaped constellation, lies to the east and north of Capricornus. It is the eleventh sign and twelfth constellation of the zodiac, and is occupied by the sun from the middle of February till the middle of March; it contains seven third magnitude and eight fourth magnitude stars. It is not conspicuous, but if attentively examined the stars in the south-eastern part of it will be found to have a trend downwards, which, doubtless, gave occasion to the idea of water flowing from a jar.



THE CONSELLATIONS ON SEPTEMBER 15, AT 8 P.M.

Piscis Australis (The Southern Fish), which is not to be confounded with the zodiac constellation of Pisces, lies to the south of Aquarius and Capricornus. Its brightest star, Fomalhaut, is the most southerly of the first magnitude stars visible in these latitudes; it is on the meridian at nine o'clock on the 20th of October, when it is only about 15° above the southern horizon.

Cepheus. one of the polar constellations, extends northward to the pole between Draco and Cassiopeia, and southward as far as Cygnus. Though a large constellation, it contains only three stars of the third magnitude and four of the fourth; however, it atones for this by the comparatively large number of interesting double and variable stars, several of the latter being of quite short period.

Mercury

Mercury will be at Inferior conjunction on September 25th, and at perihelion on October 8th. On October 11 the planet will be at its greatest elongation west from the sun; when it may be seen in the evening sky, about 27° above the setting sun. During the latter part of the month, the moon, Mercury, Venus, Mars and Jupiter will cluster about the sun, but will be too close to it to be readily seen.

Venus

Venus will be at perihelion on September 16th, and at its greatest heliocentric latitude north, on the 8th of October. Venus is still morning star and will be in conjunction with the moon, on the mornings of October 1st and 31st.

Mars

Mars, during September and October, will move through Leo and Virgo, but will be too close to the sun to be readily seen. On September 27th Mars will be in conjunction with the sun.

Jupiter

Jupiter is rapidly moving through Virgo, and will be in conjunction with the sun on October 18th.

Saturn

Saturn is in the constellation Pisces, and will be at opposition from the sun on the night of October 26th, when it will be above the horizon during the whole of the night.

Uranus

Uranus will be stationary in right ascension, low down in the south, in Sagittarius, on September 30th, after that date its motion will be direct.

Neptune

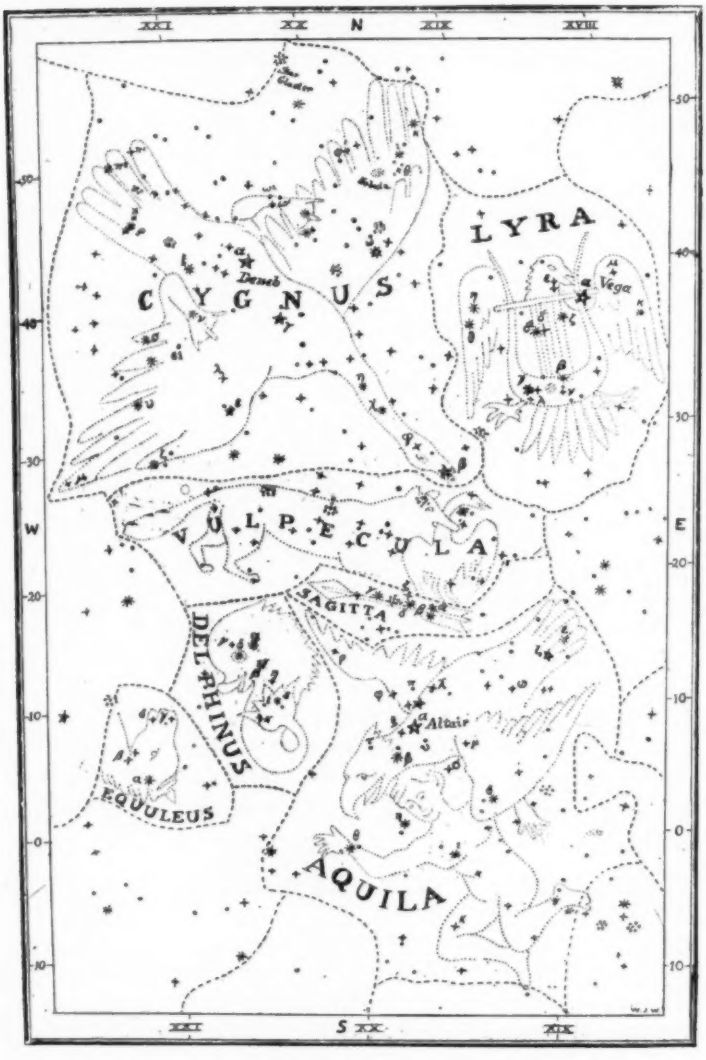
Neptune is in the morning sky, in the constellation Gemini. It will be 90° from the sun on October 15th, and will be stationary in right ascension on the 25th.

Double Stars for Small Telescopes

β Cygni. R. A. 19h 27m; Dec. 29° 45′ N. Webb gives magnitudes 3, 5·3 and distance 34″·3. Young gives 3·5, 7 and 35″. Klein gives 3, 5 and 34″. Burnham gives 3, 5·3 and 34″·29, the same as Webb. This is the finest of the colored pairs for a small telescope. The colors are orange and small-blue (Young), yellow and blue (Webb), reddish-yellow and blue (Klein), yellow and blue (Burnham). The colors can be seen beautifully by putting the stars out of focus. The colors are actually complementary, not simply by contrast. The brighter star is variable but the variations are not important. Huggins photographed the spectra of the two components separately and found the brighter to be of Class II., the fainter of Class I.

μ Cygni. R. A. 21h 40m; Dec. 28° 18′ N. Magnitudes 4 and 5; distance 5″·6 (Webb); 5, 6 and 3″·8 (Young). A third star is of magnitude 7, is at a distance 209″ and Burnham saw another of 11·5 magnitude at distance 35″.

61 *Cygni*. R. A. 21h 2m; Dec. 38° 13′ N. Magnitudes 5·5, 6; distance 22″·5. In 1831 the distance was 15″·5 and it has been steadily increasing since then. This was the first star of which Bessel (1838) was able to measure the parallax and to


XXI
XX
N
XIX
XVIII
LYRA
CYGNUS
Deneb
Vega
VULPECULA
SAGITTA
DELPHINUS
Altair
EQUULEUS
AQUILA
W
E
S
XXI
XX
XIX

deduce therefrom its distance from us. The distance is about 550,000 times the sun's distance. As far as known it is our second nearest neighbor.

χ^1 *Cygni*. R. A. 19h 43m ; Dec. 33° 30′ N. Magnitudes 5 and 8 ; distance 26″. Yellow and blue.

π *Aquilæ*. R. A. 19h 44m ; Dec. 11° 34′ N. Magnitudes 6 and 7 ; distance 15″. A good test for a 3½-inch telescope.

α *Capricorni*. R. A. 20h 12m ; Dec. 12° 50′ S. A pretty pair with a low power. Magnitudes 3 and 4 ; distance 6′ 13″. Can be seen with naked eye. The fainter star has a very faint companion not visible with any telescope of less than 6-inch aperture.

β *Capricorni*. R. A. 20h 15m ; Dec. 15° 5′ S. Magnitudes 3·5, 7 ; distance 3′ 25″. The fainter star is a close and difficult double. Very fine large field.

ζ *Aquarii*. R. A. 22h 24m ; Dec. 0° 32′ S. Magnitudes 4, 4·5 ; distance 3″. Easy and pretty. Measures of this star show that during the last eighty years the distance has slowly decreased. The period as a binary has been computed by Doberck as 1578 years, but Burnham considers this of little value. "Neither by computation nor conjecture can any one at this time be reasonably certain of naming a period which shall be within one thousand years of the correct time. As a matter of fact, it is not yet satisfactorily proven that this is a binary at all. So far as the observations are concerned it might be a system of the 61 *Cygni* type, where the change is apparently due to a small difference in the proper motions of the components. The probabilities, however, are that the change is due to orbital motion." —*Burnham*.

12 *Aquarii*. R. A. 20h 59m ; Dec. 6° 13′ S. Magnitudes 6 and 8 ; distance 2″·8. Yellowish white and light blue. Brightest star in the vicinity, 7° due west of β *Aquarii*.

β *Cephei*. R. A. 21h 27m ; Dec. 79° 7′ N. Magnitudes 3, 8 ; distance 13″·6. Greenish-white and blue.

δ *Cephei*. R. A. $22^h\ 25^m$; Dec. 57° 54′ N. The brighter star varies in magnitude from 3·7 to 5; fainter, magnitude 7. Distance 41″. Yellow and blue. This is a very fine pair, somewhat like β *Cygni*. The period of the variable star is $5^d\ 8^h\ 48^m$; discovered by Goodricke.

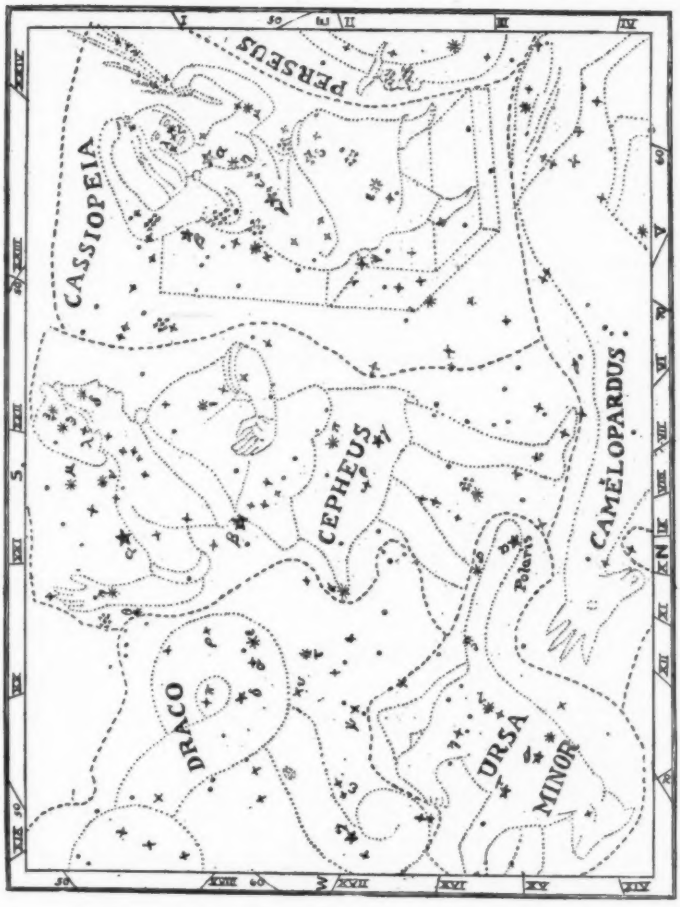
κ *Cephei*. R. A. $20^h\ 12^m$; Dec. 77° 25′ N. Magnitudes 4, 8; distance 7″·5. Colors, yellow and blue.

Clusters and Nebulæ

Cluster in Cygnus. R. A. $21^h\ 28^m$; Dec. 47° 54′ N. About 3° north of ρ *Cygni*; ρ is located by drawing a line from δ through α, and carrying it an equal distance beyond. This is a large and beautiful cluster discovered by Messier in 1764.

H. VIII. 56. R. A. $20^h\ 19^m$; Dec. 40° 20′ N. A beautiful group, ½° north and a little east of γ *Cygni*. "The bright spots in the Milky Way all through *Cygnus* afford beautiful fields for a low power."—Young. Webb remarks: "I had at one time projected a survey of the wonders of this region with a sweeping power; but want of leisure, and unsuitable mounting, and the astonishing profusion of magnificence, combined to render a task hopeless for me which, I trust, maybe carried through by some future observer."

Dumb-Bell Nebula in Vulpecula. R. A. $19^h\ 54^m$; Dec. 22° 23′. Just visible in a 1¼-inch finder. First discovered by Messier in 1764 and described as an oval starless nebula. A 4-inch refractor shows two contiguous nebulæ of moderate brilliancy, surrounded by some stars. This was all that was shown by the great telescopes of the Herschels. Recent photographs (see Roberts's volume; or the Keeler *Memorial Volume*, plate 60; or Moulton's *Introduction to Astronomy*, page 544), indicate that the outline is a complete oval. The nebula, according to Huggins's spectroscopic observations, shows a bright-line spectrum indicating that it is a mass of luminous gas.



*M.*11. R. A. $18^h\ 45^m$; Dec. 6° 24′ S. The portion of *Aquila* appropriated by Hevelius for his constellation of *Scutum Sobieski* just includes this cluster. Discovered by Kirch in 1681. A fine fan-shaped group of stars in the Milky Way, visible with a 3½-inch refractor.

AT GREENWICH MEAN NOON

Date 1910	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Sub. from / Add to Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Thur. 1	244	10 39 13·79	N. 8 31 0·6	0 9·05	10 39 4·74
Sun. 4	247	10 50 6·46	7 25 18·4	0 47·92	10 50 54·40
Wed. 7	250	11 0 56·83	6 18 30·9	1 47·23	11 2 44·06
Sat. 10	253	11 11 45·25	5 10 47·6	2 48·46	11 14 33·72
Tues. 13	256	11 22 32·25	4 2 17·7	3 51·12	11 26 23·38
Fri. 16	259	11 33 18·31	2 53 10·2	4 54·73	11 38 13·04
Mon. 19	262	11 44 4·02	1 43 33·8	5 58 09	11 50 2·7
Thur. 22	265	11 54 50·03	0 33 37·2	7 2 33	12 1 52·36
Sun. 25	268	12 5 36·98	S. 0 36 32·0	8 5·04	12 13 42·02
Wed. 28	271	12 16 25 48	1 46 44·5	9 6·21	12 25 31·69

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena

			Minima of Algol	Configuration of Jupiter's Satellites at 19h 0m
			h m	
Thur.	1	15h 02m ☌ ♀ ☾, ♀ 4° 26′ S.		432○1
Fri.	2			431○2
● Sat.	3	13h 5m·7 New Moon.	11 25	432○1
Sun.	4	1h 41m ☌ ♂ ☾, ♂ 3° 55′ S.		423○●
Mon.	5	13h 6m ☌ ☿ ☾, ☿ 7° 25′ S.		41○23
Tues.	6	7h 53m ☌ ♃ ☾, ♃ 2° 3′ S.	8 14	4○123
Wed.	7			421○3
Thur.	8			234○1
Fri.	9	5h·8 ☾ in Apogee.	5 3	31○24
Sat.	10			♃3○14
☽ Sun.	11	15h 10m·6 First Quarter.		231○4
Mon.	12	21h ☿ Stationary.	1 52	1○234
Tues	13			○1234
Wed.	14	5h 41m ☌ ♅ ☾, ♅ 3° 56′ N.	22 41	21○34
Thur.	15	7h ☿ Greatest Hel. Lat. S.		2○314
Fri.	16			31○42
Sat.	17	0h ♀ in Perihelion.	19 30	
☉ Sun.	18	23h 52m·3 Full Moon.		
Mon.	19			
Tues.	20		16 19	
Wed.	21	5h·4 ☾ in Perigee; 18h 30m ☌ ♄ ☾, ♄ 1° 31′ S.		
Thur.	22			
Fri.	23	17h ☉ enters ♎. Autumn commences.	13 8	
Sat.	24	22h ☌ ☿ ♂, ☿ 4° 10′ S.		
☾ Sun.	25	15h 53m 7 Last Quarter.		
Mon.	26	3h ☌ ☿ ☉ Inferior	9 57	
Tues.	27	0h 34m ☌ ♆ ☾, ♆ 5° 10′ S.; 12h ☌ ♂ ☉.		
Wed.	28			
Thur.	29		6 46	
Fri.	30			

Key to Symbols.—☌ Conjunction; ☍ Opposition; □ Quadrature; ☊ Ascending Node; ☋ Descending Node; ☉ Sun; ☿ Mercury; ♀ Venus; ⊕ Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; ♆ Neptune.

AT GREENWICH MEAN NOON

Date 1910	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation Time Add to Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Sat. 1	274	12 27 16·05	S. 2 56 51·1	10 5·30	12 37 21·34
Tues. 4	277	12 38 9·14	4 6 41·7	11 1·87	12 49 11·01
Fri. 7	280	12 49 5·23	5 16 5·9	11 55·43	13 1 0·66
Mon. 10	283	13 0 4·80	6 24 53·5	12 45·52	13 12 50·33
Thur. 13	286	13 11 8·33	7 32 54·0	13 31·65	13 24 39·90
Sun. 16	289	13 22 16·35	8 39 57·7	14 13·30	13 36 29·65
Wed. 19	292	13 33 29·36	9 45 54·1	14 49·96	13 48 19·31
Sat. 22	295	13 44 47·98	10 50 34·0	15 21·00	14 0 8·98
Tues. 25	298	13 56 12·72	11 53 47·8	15 45·92	14 11 58·64
Fri. 28	301	14 7 44·07	12 55 24·5	16 4·29	14 23 48·30
Mon. 31	304	14 19 22·16	13 55 13·3	16 15·87	14 35 37·97

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena

			Minima of Algol	Configuration of Jupiter's Satellites.
			h m	
	Sat. 1	10h ♃ Stationary; 7h 7m ☌ ☿ ☾, ☿ 3° 9′ S; 23h 42m ☌ ♀ ☾, ♀ 3° 2′ S.		
	Sun. 2	21h 9m ☌ ♂ ☾, ♂ 3° 2′ S. [☌ ☿ ☾, ☿ 5° 25′ S.	3 35	
●	Mon. 3	3h 32m New Moon; 8h ☌ ☿ ♀, ☿ 1° 55′ S.		
	Tues. 4	3h 01m ☌ ♃ ☾, ♃ 1° 31′ S.; 7h ☿ ♈; 11h ☿		
	Wed. 5	[Stationary	0 24	
	Thur. 6			
	Fri. 7	2h 2 ☾ in Apogee.	21 15	
	Sat. 8	22h ☿ in Perihelion.		
	Sun. 9	3h ♀ Greatest Hel. Lat. N.		
	Mon. 10		18 4	
☽	Tues. 11	8h 40m First Quarter; 15h 03m ☌ ♃ ☾, ♃ 4° 7′ N.;		
	Wed. 12	[16h ☿ Great Elong. W. 18° 3′		
	Thur. 13		14 53	
	Fri. 14			
	Sat. 15	9h □ ♃ ☉; 14h □ ♆ ☉.		
	Sun. 16		11 42	
	Mon. 17			
○	Tues. 18	9h 24m·4 Full Moon; 0h ☌ ♃ ☉.		
	Wed. 19	10h·2 ☾ in Perigee; 1h 12m ☌ ♄ ☾, ♄ 1° 28′ S.;	8 31	
	Thur. 20	[5h ☿ Greatest Hel. Lat. N		
	Fri. 21			
	Sat. 22	18h ☌ ♀ ♂, ♀ 0° 45′ N.; 6h 50m ☌ ♆ ☾, ♆ 5° 20′ S.	5 20	
	Sun. 23			
	Mon. 24			
☾	Tues. 25	0h 47m·9 Last Quarter; 10h ♆ Stationary.	2 9	
	Wed. 26			
	Thur. 27	4h ☌ ♄ ☉; 7h ☌ ☿ ♂, ☿ 1° 5′ N.	22 58	
	Fri. 28	6h ☌ ♀ ♃, ♀ 0° 11′ N.		
	Sat. 29	20h ☌ ☿ ♃, ☿ 0° 20′ N.		
	Sun. 30	[♃ 0° 58′ S.	19 47	
	Mon. 31	18h 28m ☌ ♂ ☾, ♂ 1° 39′ S.; 21h 36m ☌ ♃ ☾.		

For Jupiter's Satellites, the circle ○ represents the disc of the planet; ♃ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc or in the shadow. Configurations are for an inverting telescope.

Cluster in Capricornus. R. A. $21^h\ 35^m$; Dec. 23° 38′ S. Described by Messier as a strip of starless nebula visible only with difficulty. It can be resolved into stars with a 5-inch refractor. Herschel saw the stars with a 10-foot reflector. According to Rosse it is of spiral form.

Nebula in Aquarius. R. A. $21^h\ 28^m$; Dec. 1° 16′ S. Discovered in 1746 by Maraldi. Beautiful round nebula of diameter 5′ or 6′. In the average telescope this appears to be of moderate brilliancy and circular with a small faint star at the eastern edge. In a 3·7-inch it shows a granulated aspect, suggestive of resolution. Sir John Herschel compares it to a heap of fine sand and considers it to be composed of thousands of 15-magnitude stars.

Nebula in Aquarius. R. A. $20^h\ 59^m$; Dec. 11° 50′ S. A beautiful, planetary nebula, discovered by Sir W. Herschel, September 7, 1782. Somewhat elliptic, bright and vividly green. Lassell saw a bright ring within the nebula, and Rosse called it "Saturn Nebula." Its spectrum, according to Huggins and Vogel, shows it to be gaseous. Keeler has shown that it is approaching the sun at the rate of 17·2 miles per second. Very beautiful photographs of this interesting object, exhibiting the "Saturn" effect are given in the Keeler *Memorial Volume* plate 64.

ECLIPSES AND TRANSITS OF THE SATELLITES OF JUPITER

E = eclipse, O = occultation, T = transit, S = shadow, D = disappearance, R = re-appearance, I = ingress, e = egress.

Eastern Standard Time; hours numbering from midnight.

SEPTEMBER

d	h	m		
3	19	15	II.	Se

V
4